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REMOVAL OF CLEOPATRA'S NEEDLE FROM EGYPT TO NEW YORK.

Through the skill of Lieutenant Commander Gorringe, of the United States Navy, backed by the splendid liberality of one of New York's citizens, Mr. W. H. Vanderbilt, who has borne the entire expense of the undertaking, the remaining "Cleopatra's Needle," which was presented some time ago by the Khedive of Egypt to the United States, has been finally safely lowered from its pedestal to the ground; and if no unforeseen accident should occur, may be expected to reach our shores in the early part of the coming summer. We present herewith a series of engravings representing the celebrated monolith, and the scenes that transpired during its removal. Before referring to these farther, however, it may not prove uninteresting to the reader if, in a few preliminary remarks, we state the purposes, proportions, material, and position of obelisks—those grand examples of Egyptian monumental art.

PURPOSES OF OBELISKS.

Obelisks are the most simple monuments of Egyptian architecture, and among the most interesting that antiquity has transmitted to us, from the remoteness of their origin, and the doubt in which we still remain as to the period when their various names and titles, they are emblems of both the perseverance and love of glory of the Egyptians and their rulers. The very fact of their being transported to Europe by the ancient Romans under their emperors shows the high value in which they were held by that people, as witnesses of their own world-wide victories in remote regions.

SIZE AND PROPORTIONS.

The Egyptians set great value upon the size of their monoliths, and if a large block was extracted from a quarry not quite corresponding in all its sides, whether as to size or form, they would without scruple use it for their immediate purpose, or shape it as near as possible to the object they had in view, without diminishing its size. The consequence is that many of their obelisks, pedestals, and sarcophagi, where one would have supposed the most scrupulous attention to uniformity should have existed, are irregular in shape. The sides of an obelisk rarely corresponded exactly with the breadth of its face, or the height of the shaft to any fixed relation with the width at the base; and there is a like disregard in the height of the pyramidion (the pyramid-like apex), which, however, was high peaked and never stunted. Nevertheless we may assume that the shaft varied from eight to nine diameters high up to the pyramidion, which itself was

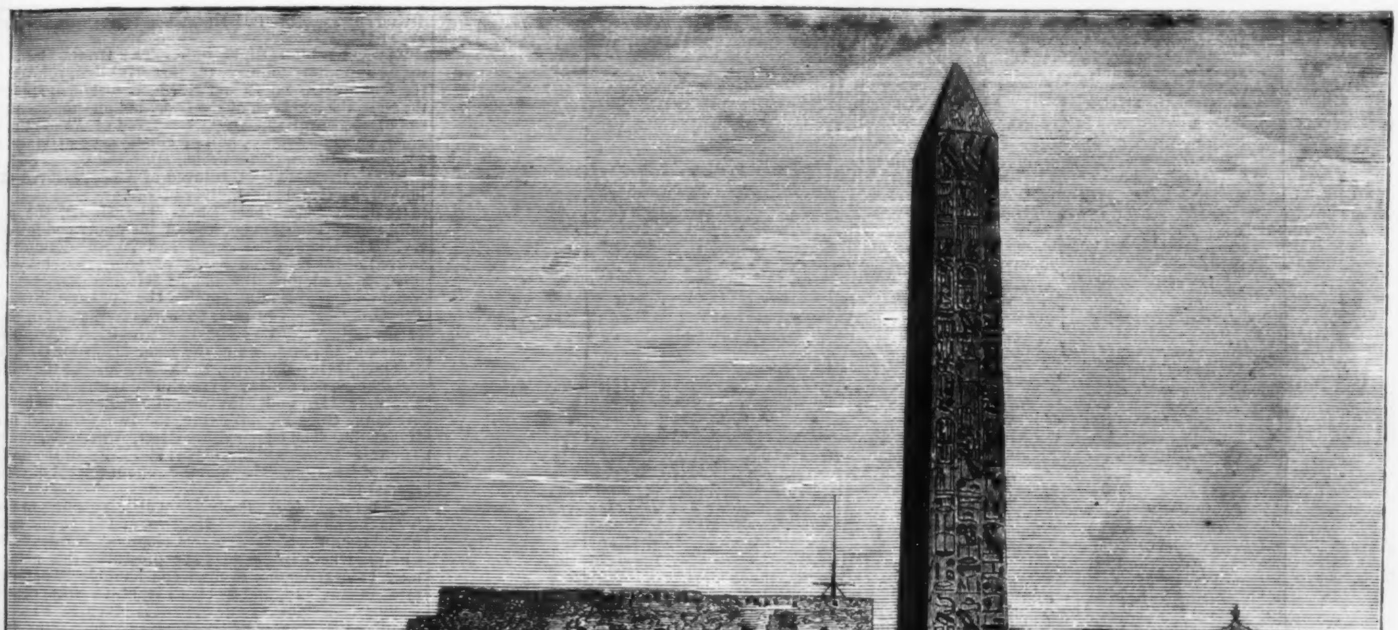


Fig. 1.—THE OBELISK PRESENTED BY THE KHEDIVE OF EGYPT TO THE UNITED STATES.

set up. The oldest which now remains to us is still standing at Heliopolis, near Cairo—the On Ramses or Beth-Shemesh of the Hebrew Scriptures. Abraham was unborn, and the Pentateuch of Moses was unwritten, when the inhabitant of Heliopolis adored his gods in the Temple of the Sun, and read upon the obelisk, still in its place, the name of Harmachis and that of King Osortisen, who then reigned and reared it, and to whom Mariette Bey assigns the date of 2,851 years B. C. Pliny says that the Egyptian term for an obelisk conveyed the idea of a sun's ray, which its form was supposed to symbolize. The term obelisk is derived from the Greek *obelos*, which meant a "spit"—a term which the witty epigrammatic Greeks gave them, with the view, like all wits in such cases, to cover with an air of ridicule what they could not controvert by reason. Obelisks have, from the earliest periods of antiquity, been regarded as remarkable monuments of the skill and perseverance of remote ages. They must ever be considered as valuable records of the ancient history of the Egyptians, and of the skill of those periods; monumental evidences of their sovereigns and their warlike exploits. Extracted with vast labor from their quarries as monoliths, conveyed six or seven hundreds of miles down the Nile and erected with difficulty in front of their temples by kings to commemorate their victories and record from sixty to seventy-five hundredths of the breadth at the base. The four sides or faces of the obelisk were usually square, but occasionally they were convex; a fact proving the nice perception for effect which prevailed in the minds of the Egyptians, as thus the light was much softer upon the surface, the shades less crude, and the angles less cutting. Some of the huge blocks intended for obelisks came from the quarry misshapen at the smaller end, and to remedy such a defect they covered it with a metal capping of the required shape rather than reduce its length by cutting off the rugged portion. The summit of the Luxor obelisk, now in Paris, was irregular in shape and quite rough, and must originally have been capped with metal. Usually, obelisks had one, two, or three vertical lines of hieroglyphs. It may be assumed that only one series was intended by the original Pharaoh; but it appears that his son, successor, or successors, added a line on each side; and it is remarkable that earlier hieroglyphs were much deeper cut than the more recent ones. Mariette Bey, the Egyptologist, mentions the fact that the faces of obelisks were sometimes gilded, the hieroglyphs themselves retaining their original color and actual surface of the granite. On the subject of the dies, pedestals, and steps upon which the monoliths were anciently raised we have little information, for the bottom portions of those now left standing are encumbered and surrounded by huge fallen blocks of stone, preventing their full size from being seen.

MATERIAL AND HOW QUARRIED.

All of the large monoliths were of pink granite taken from the quarries of Syene. The position of these quarries must have been of the utmost importance in facilitating the application of that fine material. Situated below the cataracts, when once the masses were extracted from their beds, no obstruction presented itself in their course down the river to their destination, whether to Memphis, Heliopolis, or the Delta. Twenty-seven of the forty-two obelisks now known were from Syene, and they are doubtless the largest. An unextracted block still remains at Syene, 95 ft. long by 11 ft. in diameter, with the quarrymen's marks on it. Sir Gardner Wilkinson states that the final operation of extraction, when three sides of a mass had been worked round, was by cutting a groove or channel about a couple of inches in depth, and kindling a fire along its whole extent. When the stone was intensely heated, cold water was poured into the groove, and the block detached itself with a clear fracture. Wedges of wood were also inserted, saturated with water, then exposed to heat, and the expansion rent the mass asunder. Thus detached it was drawn down to the river, where it was incased, or upon a galley or raft floated down the Nile to near the spot where it was ultimately to be set up. From the river bank it was then hauled up to the Propylea in front of which it was to stand. There are no hieroglyphics or paintings extant to show us how the obelisk was raised and placed in its final position. That this was a most critical operation is obvious, and its difficulty is illustrated by an anecdote related by Pliny: Rameses erected an obelisk 140 cubits high and of prodigious thickness. It is said 120,000 men were employed on the work. To insure the safety of the operation by the extremest skill of the architect, he had his own son fastened to the summit while it was raised.

As to the tools used in carving the granite we know nothing. Hardly any iron tools have been preserved among the relics of the tombs. With what material did the Egyptians sculpture with such refined delicacy and exquisite sharpness the mouth, eyes, ears, and other features of their statues, and the sharp contours of their hieroglyphs? We are possessed of no process by which brass may be sufficiently hardened for the purpose. Could they have softened the surface by some chemical application on the harder elements of the stones? No one has as yet been able to inform us,

and the secret mystery of the execution of the Egyptian sculpture still excites our wonder and admiration.

WHERE THE OBELISKS WERE PLACED.

The positions of obelisks were before the gigantic pylons which formed the entrance gateways to the fore courts of their temples, and they were without exception always in pairs. At Karnac the situation of the two lofty ones erected by Queen Hatsou (one of which still stands, and is 108 ft. 6 inches high, the tallest one known) was between two lofty pylons only 40 to 50 feet apart. Those in front of the outer pylon are not so distant in advance of it. Consequently the Egyptians disregarded the immediate proximity of a high wall backing them up, and none are known situated in wide open spaces. The sacred way led up from the river, flanked on each side with variously headed sphinxes. At Karnac the dromos is one mile and one-third long, with a line of sphinxes on each side. Approaching nearer, the worshiper finds two obelisks on the right and left, not necessarily of the same height. At Luxor one is 7 or 8 feet higher than the other, and to diminish the appearance of disparity in size, the shorter one is raised on a lofty pedestal and brought some feet in advance of its companion. Attached to the face of the pylon are six gigantic sitting statues of kings, majestic in size and seated in the hieratic posture. The pylon itself, perhaps 200 feet wide and 100 feet high, forms the background of the whole, crowned by its cavetto cornice, and its surface covered with the colored sculptures of the victorious Rameses in his chariot, with upraised arm, slaying his enemies, trampling them under his horses' hoofs, and alone dispersing them in flight. In the center of the structure is the portal, 56 feet high, through which the sacred or triumphal procession passed in all its gorgeousness to within the sacred precincts, there to observe the ritual ceremonials of the mysterious Egyptian cult of one or more of their eight great divinities or animal gods. Erasmus Wilson, in his book entitled "Cleopatra's Needle" (p. 178), enumerates the existing obelisks as follows: Rome, 12; Italy, in addition, 4; Egypt, 6; Constantinople, 2; France, 2; England, 6; Germany, 1.

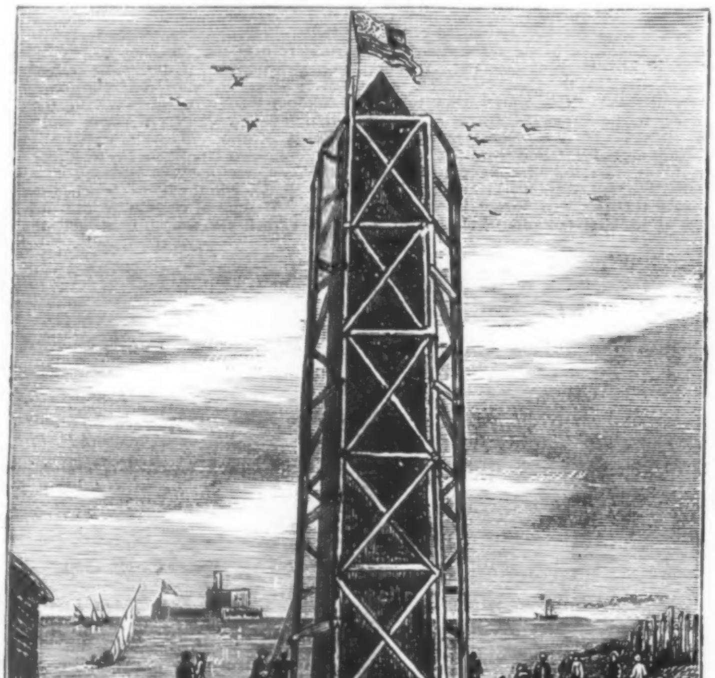


FIG. 2.—INCASING THE OBELISK.

CLEOPATRA'S NEEDLES.

For nearly 2,000 years there have stood on the shores of the Levant, near Alexandria, two obelisks of rose-colored granite known as "Cleopatra's Needles." We are told by Egyptologists that they were taken from the quarries at Syene, and thence conveyed to Heliopolis, where by Sesostris they were set up before the entrance to the temple of the god Tum, or the Setting Sun. Pliny states that they were transported to the Nile with the aid of flat-bottomed boats, floating in canals specially prepared for the purpose. Sharpe says that they were placed in an erect position by cutting a groove in the pedestal, in which the lower edge of the monolith might turn as if it were a hinge, the top of the shaft being elevated by means of a mound of earth, the size of which was continually increased till the stone stood securely erect. The obelisks were brought to Alexandria during the reign of Tiberius, but bear their present popular name because of a tradition that they were taken to Alexandria in the time of Cleopatra. Their age is estimated to be about 3,300 years. One of the obelisks has until recently been standing where it was originally placed when brought to Alexandria, but the other, which is the less perfect of the two, has for many years been lying prostrate on the sand. In 1819, Mehemet Ali offered the fallen monolith to the Prince Regent of England, and the British Government accepted the gift, but afterwards declined to act in the matter because of the expense attending removal. In 1851, the subject was again brought up; but, as before, no action was taken. Finally, in 1876, Dr. Erasmus Wilson concluded to pay the expenses himself of transporting the great monolith, and bargained with Mr. John Dixon, a well known engineer and contractor, to bring it to England and erect it on the Thames Embankment for \$50,000. Both of these "Needles"—the one transported to England, and its more perfect companion recently presented to the United States by the Khedive of Egypt—possess great historical value, aside from that sentimental estimation which enlightened nations place upon all monuments of antiquity. As far as known the hieroglyphics on the obelisk which is coming to this country have never been deciphered, but as both obelisks are of the same age, and came originally from the same city and temple, it is not unlikely that the inscriptions refer to the same, or, at least, to similar subjects. When the London obelisk was unearthed, it was found to be just 68 feet long, and its weight about 200 tons. The hieroglyphics which covered each of its four faces were washed, and then deciphered by Brugsch Bey, the eminent Egyptologist. He found that they referred to the lives of the two Kings, Thothmes III. and Rameses II. Subsequently a correct translation of the whole has been made by Dr. Samuel Birch, of the British Museum, and is as follows:

"First Side, Central line, towards east when erected on Embankment.—The Horus, lord of the upper and lower country, the powerful bull; crowned in Uas or Thebes, the King of the North and South Ramen Cheper has made his monument to his father, Haremachu (Horus in the horizons), he has set up to him two great obelisks, capped with gold, at the first time of the festivals of thirty years, according to his wish he did it the son of the Sun Thothmes (III.) type of types did it beloved of Heremachu (Horus of the horizons) ever living.

"First Side—Left Line.—The Horus of the upper and lower country, the powerful bull, beloved of the Sun, the King of Upper and Lower Egypt, Ra-user-ma, approved of the Sun, lord of the festivals, like Ptah-Tanen, son of the Sun, Rameses beloved of Amen, a strong bull, like the son of Nu (Osiris), whom none can withstand, the lord of the two countries, Ra-user-ma, approved of the Sun, son of the Sun, Ramessu (II.), beloved of Amen, giver of life, like the Sun.

"First Side—Right Line.—The Horus of the upper and lower country, the powerful bull, sun of Tum, King of the South and North, lord of diadems, guardian of Egypt, chastiser of foreign countries, son of the Sun Ramessu (II.), beloved of Amen, dragging the South to the Mediterranean Sea, the North to the Poles of Heaven, lord of the two countries, Ra-user-ma, approved of the Sun, son of the Sun Ramessu (II.), giver of life, like the Sun.

"Second Side—Central Line, towards river (south), as erected on Embankment.—The Horus of the upper and lower country. The powerful bull, crowned by Truth. The King of the North and South, Ramen Cheper. The lord of the gods has multiplied to him festivals on the great Persea tree in the midst of the place of the Phœnix (Heliopolis). He is recognized as his son, a divine chief, his limbs come forth daily as he wishes, the son of the Sun Thothmes (III.), ruler of An (Heliopolis), beloved of Haremachu (Horus in the horizons).

"Second Side—Left Line.—The Horus of the Upper and Lower country, the powerful bull, beloved of Truth, King of the North and South Ra-user-ma, approved of the Sun, born of the gods, holding the two lands (of Egypt), as the son of the Sun, Ramessu (II.), beloved of Amen, making his frontier wherever he wished, who is at rest through his power, the lord of the two countries, Ra-user-ma, approved of the Sun, son of the Sun, Ramessu beloved of Amen, the luster of the Sun.

"Second Side—Right Line.—The Horus of the upper and lower country, the powerful bull, son of the god Chepera, the King of the North and South, Ra-user-ma approved of the Sun. The golden trait, rich in years, the most powerful, the eyes of mankind behold what he has done, nothing has been said in opposition to the lord of the two countries, Ra-user-ma approved of the Sun, the son of the Sun, Ramessu (II.), beloved of Amen, giver of life, like the Sun.

"Third Side—Central Line, West side as erected on Embankment.—The Horus, lord of the upper and lower country, the powerful bull, beloved of Truth, the King of the South and North Ramen Cheper. His father Tum has set up to him his great name, placing it in the temple belonging to An (Heliopolis), giving him the throne of Seb, the dignity of Cheper, the son of the Sun, Thothmes (III.), good and true, beloved of the Spirits of An (Heliopolis), ever living.

"Third Side—Right Line.—The Horus of the Upper and Lower country, the powerful bull, well-beloved of Ra, the king of the South and North Ra-user-ma, approved of the Sun, lord of festivals of 30 years, like his father Ptah, son of the Sun, Ramessu (II.), beloved of men, son of Tum, beloved of his loins; Athor, the goddess, directing the two countries, has given him birth, the lord of the two countries, Ra-user-ma, approved of the Sun, the son of the Sun, Ramessu (II.), beloved of men, giver of life, like the Sun.

"Third Side.—Left Line.—The Horus, lord of the two countries, the powerful bull, son of the Shu, the King of the South and North, Ra-user-ma approved of the Ra, the lord of diadems, director of Egypt, chastiser of foreign lands, son of the Sun, Ramessu (II.), beloved of Amen, bringing his offering daily in the house of his father Tum, not has been done as he did in the house of his father the lord of the two countries, Ra-user-ma, approved of the Sun, the son of the Sun, Ramessu (II.), beloved of Amen, giver of life, like the Sun.

"Fourth Side and Central Line towards Road (North), as erected on Embankment.—The Horus of the Upper and lower country, beloved of the god of the tall, upper crown, the King of the South and North, Ramen Cheper, making offerings, beloved of the gods, supplying the altar of the Spirits of An (Heliopolis), welcoming their persons at the two times of the year, that he might repose through them with a sound life of hundreds of thousands of years with very numerous festivals of thirty years, the son of the Sun, Thothmes (III.) the divine ruler, beloved of Haremachu (Horus in the horizons) ever living.

"Fourth Side—Right Side.—The Horus, lord of the upper and lower country, the powerful bull, beloved of Ra, the King of the South and North, Ra-user-ma, approved of the Sun, the sun born of the gods, holding the countries, the son of the Sun Ramessu (II.), beloved of Amen, the strong hand, powerful victor, bull of rulers, king of kings, lord of the two countries, Ra-user-ma, approved of the Sun, son of the Sun, Ramessu (II.), beloved of Amen, beloved of Tum, lord of An (Heliopolis), giver of life.

"Fourth Side.—Left Line.—The Horus, the powerful bull, son of Ptah-Tanen, lord of the upper and lower country. The King of the South and North, Ra-user-ma, approved of the Sun, the hawk of gold, rich in years, the greatest of victors, the son of the Sun Ramessu (II), beloved of Amen, leading captive the Rutennu (Syrians) and Peti (Libyans) out of their countries to the seat of the house of his father, lord of the two countries, Ra-user-ma, approved of the Sun, son of the Sun, Ramessu (II.), beloved of Amen, beloved of Shu, the great god, like the Sun.

"The scenes on the pyramidion represent the monarch Thothmes III., under the form of a sphinx, with hands offering to the Gods Ra and Atum, the two principal deities of Heliopolis. The offerings are water, wine, milk, and incense. The inscriptions are the names and titles of the deities, the titles of Thothmes III., and the announcement of each of his special gifts.

As before stated, the obelisk which is coming to this country is the more perfect of the two, and is the one usually referred to in the books as *the* "Cleopatra's Needle." The fact that the Khedive should have presented this noble monument to America has excited considerable ill-natured comment in England, and has been regarded with considerable jealousy. A view of our obelisk is given in Fig. 1. The temple at Heliopolis where these two monoliths originally stood is of interest, to biblical students, as it is supposed to be one in which Moses became learned in all the wisdom of Egypt. When the inscription on our "Needle" shall have been deciphered, further light may be shed upon the history of the remote past in Egypt, which is so profoundly connected with the whole rise and progress of the religions, the philosophies, and the arts of our own race and our own times.

METHODS OF LOWERING AND TRANSPORTING THE OBELISK.

The method of lowering and of transporting the obelisk to this country is entirely original with Lieutenant Commander Gorringe, who has been intrusted with the entire matter. The gigantic framework to be used in lowering the monolith was shipped for Liverpool, Oct. 7th, 1879, on board the Guion steamer Nevada.

From Liverpool it was transhipped to Alexandria, where it arrived safely, and the work of erection immediately begun. The machinery was constructed at the works of Messrs. Roebling's Sons Company, at Trenton, after plans made by Lieut. Commander Gorringe, its total weight being 128,000 pounds. The first operation after arriving at Alexandria was, after erecting the proper scaffolding (Fig. 2), to incase the monolith with 2-inch oak planking, bound at intervals of 3 feet with strong iron bands. Then the obelisk was guyed at the top from four points, like the mast of a vessel, so that there could be no possibility of its falling over (Fig. 3). The center of gravity had been calculated at a point of 26 feet above the base, and here trunnions were placed on either side and bolted across the sides by eight $1\frac{3}{4}$-inch iron and four 2-inch steel bolts. The trunnions were cast from cannon metal only, and that of the best quality. The trunnion plates were 4 inches thick, 9 feet wide, and 6 feet high. At the center was the turned trunnion, 33 inches long, and 18 inches in diameter. The weight of each trunnion and plate was 1,250 pounds, making together $1\frac{1}{4}$ tons. The next operation was to quarry out four 6-in channel ways through the base of the obelisk, and insert I beams to assist in raising the foundations. Next the foundations were constructed. These consisted of two platforms, one on each side, of 3-inch oak planking, each 6 feet wide and 24 feet long. On top of these were set four oak sticks, 12 by 18, firmly bolted together. The iron work of the towers was then built on top of the preliminary foundation. Each tower was constructed of six 12-inch heavy wrought iron I beams, spreading out at the base to a distance of 21 feet, and converging at

the top to within 5 feet. The beams at their base rested on four heavy I beams, and were securely riveted to the platform by means of plates and knees. Placed on top of these posts were caps, each 5 feet long and 30 inches wide, which also were secured by means of plates and knees. The posts were braced from top to bottom by angles and channel irons, making the towers perfectly rigid. Placed on top of the caps, and securely bolted to the tower proper, were cast iron journals weighing 3,700 pounds, each forming the grooves for the trunnions to work in. A 6-inch rib had been cast in the bottom of each of the trunnions, and in these ribs were four 2-inch holes. Through each of these holes 1¾-inch iron rods were inserted connected with similar rods from the 6-inch I beams running through the base, by means of right and left thread turn buckles, which were used to raise the obelisk from its foundation, and throw the weight on the trunnions. On the 6th of December, everything being ready, the monolith was successfully raised in the presence of 5,000 people who had come to witness the operation; the foundation was then removed, and the obelisk left hanging free. The obelisk having been turned over to a horizontal position, Capt. Gorringe next proceeded to build two piles of beams placed crosswise; and, as soon as they reached the height of the stone, jacks were used to lift the latter out of its trunnion bearings and block it up. All the construction was then removed, and, foot by foot, the obelisk was lowered to the ground by reducing the piles, first from one side and then from the other. On the ground the obelisk was incased in an iron cradle, consisting of a parabolic truss on each side, connected by means of heavy channel flow beams and braces. To the flow beams two heavy channel bars were riveted, and corresponding channels were laid on the ground to form the track for the obelisk to move on, the movement being effected by inserting 8-inch cannon balls into the grooves formed by the channel bars, and the track being laid 60 feet ahead of the cradles, so that as the stone was pushed along, the track behind was taken up and placed in front. From the base of the obelisk to the sea a trench had been dug, which, at the end near the sea, is 95 feet long by 30 feet broad, and 16 feet deep; in this portion a float, constructed for the purpose, will be used to transport the obelisk to the port of Alexandria, a distance of about a mile in a straight line. In digging the pit around the base of the monolith, Capt. Gorringe discovered that the shaft stood on a pedestal, the existence of which was before unknown. It

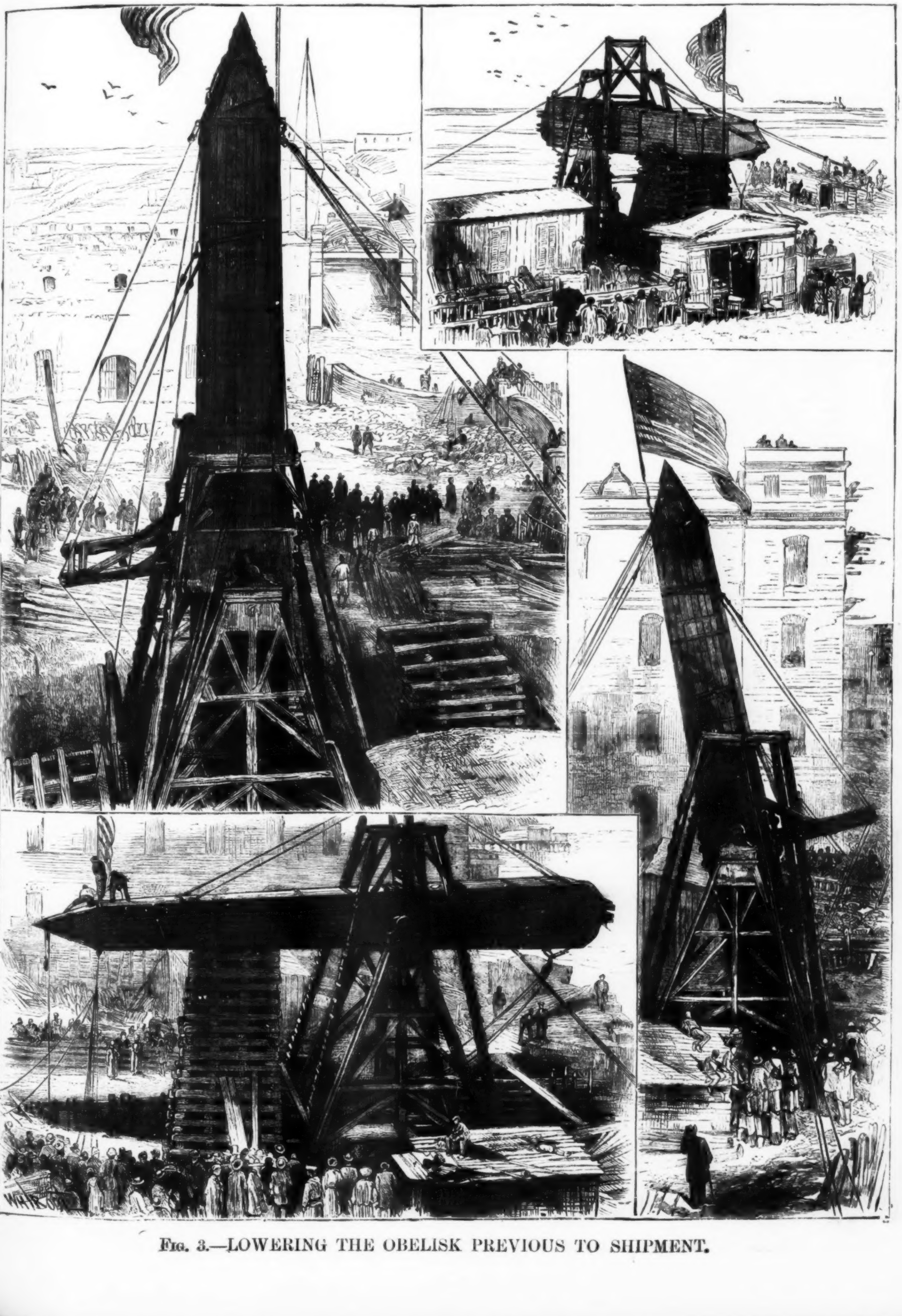


FIG. 3.—LOWERING THE OBELISK PREVIOUS TO SHIPMENT.

was 9 feet square, 7 feet in height, and rested upon three well preserved marble steps with a base of masonry. From the lower surface of the lower step the obelisk rises 81 feet 2½ inches to its summit, and its estimated weight is about 196 tons. At the port of Alexandria the obelisk will be placed on a large ship selected for the purpose, and so brought to this country. This plan is very different from that adopted by the English engineer, which, it will be remembered, was to inclose the obelisk in a cylindrical vessel formed of wrought iron plates, and provided with water-tight compartments. This, after being rolled into the sea, and towed to the harbor, was ballasted and provided with a keel, deck, sail, and rudder. The vessel was then placed in charge of two or three skilled mariners, for whom a small cabin on deck was provided, and towed to England by a steam-tug, the sail being simply for steadying the cylinder. Should our obelisk reach port in safety the same machinery, with very slight modification, will be used to place it in an erect position, after a proper site has been selected for it.

There can be no doubt that our citizens, as they pass by this obelisk after its erection, will have their curiosity excited by the sight of hieroglyphs which have probably been seen and read by the Jews at the time of Moses, or when the Saviour was taken by his parents to Egypt as a place of refuge from Herod's rage.

The following is a list of the more notable obelisks, with their present sites, sizes, etc.:

OBELISKS.

Present Site.	Size.	Height.	By or to whom Dedicated.
	ft. in. ft. in.	ft. in. ft. in.	
Heliopolis	6 1 × 6 3	68 2 or 66 6	Osortisen, 2,851 B. C.
Biggeg-Crocodopolis	6 9 × 4 0	43 ft. 0 in.	Ditto.
Karnak		90 6	Thothmes I.
Ditto	Mariette.	108 10	Hatasou, 1,660 B. C.
Lateran, Rome	9 8 × 9 10	105 6	Thothmes III.
Vatican, Rome	8 10	82 9	No hieroglyphs.
Alexandria*	7 7 × 8 2	70 0	Thothmes III.
London	7 10¼ × 7 8	68 5½	Ditto.
Constantinople	Broken.	50 0	Ditto.
Sion House	0 10¾	7 6	Ditto.
Thebaid, Alnwick	0 9¾ × 0 9	7 3	Amenotep II.
Porta del Popolo, Rome	8 5 × 8 5	78 6	Seti Menepthah I.
Trinità dei Monti, Rome	4 3	43 6	Ditto.
Luxor		82 0	Rameses II.
Paris	8 0 × 8 0	76 4	Ditto.
San, or Tanis			Ditto.
Monte-Citorio, Rome		71 5	Sesostris.
Piazza Navona, Rome	4 5	54 3	
Pantheon, Rome	Fragment.	50 0	Ditto.
Villa Mattei, Rome	8 3		
Piazza Minerva, Rome	Fragment.	17 0	
British Museum, 2	1 6 × 1 5	8 2	Amyrtæus I.
Constantinople	6 0 × 6 0	35 0	Nectancho I.
Corfe Castle, Philæ	2 2	22 1½	Ptolemy Evergetes II., 150 B. C.
Benevento		9 0	
Monte Pincio, Rome		30 0	Hadrianus.

* Presented to the United States.

EGYPTIAN ANTIQUITIES.

THE tomb of Nofre Ma, an Egyptian of the third dynasty, which was discovered seven or eight years ago at Meidoum, is represented in the illustration we have been permitted to borrow from a new work on Egypt called "Nile Gleanings," by Mr. Villiers Stuart, of Dromana, published by John Murray. In this book drawings will be found of many of the most recent discoveries, as well as descriptions of them. The author, although he speaks modestly of his own attainments in Egyptology, has evidently given considerable time and care to the study. The knowledge thus acquired has enabled him to produce a book of great value to the Egyptologist from the data he has collected, some of it being entirely new. Although learned, and full of information about ancient dynasties and their monumental remains, the work is not only scientific, but is, at the same time, a readable and delightful book of travel. It contains a narrative of a voyage up the Nile as far as the Second Cataract, full of details of the present condition of Egypt. The volume is furnished with no less than fifty-eight plates, most of them printed in colors, and done from drawings made on the spot by the author. By means of the color a better idea of Egyptian art may be formed than what is possible from merely outline illustrations, the work thus possessing a very marked advantage over others of its kind. The author more than once refers to his illustrations as proof that the ancient Egyptians were of a race more allied to the people of Europe than to the Hamitic tribes of Africa. In this he is most probably right, for, except in Abyssinia, at Axum, there are no monuments of the past in Africa, and the Abyssinians are not Hamitic, but Shemitic; and there appears strong evidence that the negro races could never have originated the art which developed into the wonderful monuments along the course of the Nile. The author seems inclined to trace Greek art to Egypt. Of course, he has the old tale of Danaus and his daughters coming from Egypt to Argos in favor of this theory. The discussion of this matter comes in at the present moment most opportunely when other theorists are endeavoring to make the Hittites the original teachers from which the Greeks derived their first lessons. To those who are familiar only with Egyptian sculpture as seen in the conventional and rigid figures of deities, kings, and sphinxes, and various sacred beings which are represented in temples, the existence of other subjects to be found in Egyptian art, and given in "Nile Gleanings," may occasion surprise. Caricature was not unknown to the ancient Egyptians, and such scenes as "Welcome Home," at p. 298, and "Behind the Door," at p. 146, represent feelings we are all familiar with, while they illustrate a point the author insists on, that the ancient Egyptians were not very different from the people of our own day; and that they trusted, hoped, and loved then, much as we do now. Many among us may know doors behind which they have acted much as Thothmes III. is represented doing about a century and a half before the time of Moses.

This tomb of Nofre Ma, as well as others at Meidoum, was discovered about seven or eight years ago, and they possess an interest from their great antiquity alone, for they are older than the Great Pyramid of Ghizeh. That belongs to the fourth dynasty, while these tombs are supposed by some authorities to be of the third. The exact date is uncertain; Lepsius makes them 3,122 B.C., or about 5,000 years old—an immense age in comparison with the monumental remains of any other part of the world. Senofreou was the Pharaoh of the time, and his pyramid still stands at Meidoum unopened. Dr. Birch places him in the fourth dynasty, but other authorities place him in the third. All are agreed that he reigned previous to Shoofoo, or Cheops, and he is said to be the most ancient monarch of which we have monumental evidence, containing his name and records of his deeds. Nofre Ma, or Nofre Maat, his name being thus variously rendered, the words meaning Good and Just, was a man of high rank, and filled the office of treasurer to Senofreou. He is represented on this tomb, and the style of art is rather peculiar, for there are deep holes cut in the rock, and these were filled up with a very hard colored cement, the colors varying in each hole like a mosaic. This early style was not continued in the later dynasties. Close by is the tomb of Nofre Ma's wife, the Princess Atot. And in one of the same group of tombs Mariette Bey found the pair of statuettes, of Ra-Hotep and his wife Nefert, also belonging to the same date, and which, although about 1,000 years older than the time of Abraham, are, thanks to the climate of the land of Chem, as fresh and perfect as if made in our own century. These recent "finds" of times so far past do not come to our European museums now; they all go to the museum at Boolak, near Cairo, hence the non-traveling portion of the public can only form a notion of them from books and drawings.—*Illustrated London News.*

TOMB OF NOFRE MA, AN EGYPTIAN OF THE THIRD DYNASTY, AT MEIDOUM.

PREHISTORIC POTTERY—THE TERRY COLLECTION.

THE advantages afforded by the spacious and fire-proof rooms of the American Museum of Natural History are naturally bringing to this city for comparison and preservation some of the most valable geological and archæological collections in the land. Among these the collection of prehistoric implements of pottery of Mr. James Terry, of Hartford, Connecticut, is one of the most important. This is the result of many years of intelligent work, and contains much that is novel and undescribed. Among the more striking objects are the stone pots from California, and the terra-cotta vases from Missouri mounds, which are described at great length in a recent issue of the *Times*.

One of the stone pots is exceedingly beautiful, and has the great diameter of 17 inches. It is nearly globular in shape, the opening being only six inches in diameter. The finish, both inside and out, is extremely fine. There are several choice serpentine pots of globular form, and handsomely finished. These vary much in size. The larger one, about 10 inches in diameter, has the smooth margin of the aperture inlaid with mother-of-pearl, in rectangular pieces, alternating with circular ones of the same material. The stone mortars are finer than any seen here before. The pestles are so carefully worked that one is nearly ready to assert their regularity could only be produced by lathe-work. The stone thus carved into ornamental as well as useful objects is of various degrees of hardness, from the volcanic to the soft sandstones and soapstones. Some of the pestles are 33 inches in length. Plates and bowls of soapstone, or steatite, are ingeniously adapted for domestic uses. The former are usually rectangular, of good size and pattern. Some are curved, and have an ornamental rim, which gives them the aspect of table ware.

The collection of pottery, in terra-cotta, is surprisingly interesting. It was reserved for Mr. Terry to show from the mounds and graves of Missouri water-jars so closely like those characteristic of South America, that they may well be assumed to be the products of the same people. Quite as remarkable are certain water-jars, having the body in the shape of the human face. Some examples are decorated in colors, the lines being mostly representations of tattooing. Considerable difference is seen in the material used. The clay of some specimens is a light fawn color, which was, probably, before burning, a delicate cream. This is much firmer in quality, and is unmixed with shell, apparently. There are numerous small terra-cotta toys, miniature cups, vases, whistles, rattles, etc One is a cup or spoon, with its handle terminated by a tolerably well-executed human hand, closed. Other vases, etc., have medallions in low relief, which appear to have been luted on after the vases were made. Some are most singularly modeled in human forms; others are square or rectangular. One example represents a human form lying upon a rectangular vase, the opening being in the abdomen.

As in our time, there seem to have been certain artisans or workers, who rose greatly above the average, and were really artists by nature, possessing an ability in modeling that is not exceeded at the present day. We constantly meet with forms of pottery bearing evidence of artistic attempts, more or less creditable, such as the modeled faces, animals, fruit, leaves, etc., but there are few very choice objects found in the same localities, and used by the same peoples, no doubt. In the mound graves of Missouri, Mr. Terry found, among the cruder vessels, one that may challenge the skill of the average sculptor of to-day. It is a dish, about 10 inches in length, modeled to represent a single valve of a species of *unio*, or fresh water mussel, common in the waters of the Western rivers. This not a cast, as its exquisite shape, both inside and outside, would suggest, but a veritable piece of modeling in clay, finished for use by baking, as other prehistoric pottery is. Its admirable execution cannot be appreciated without inspection. It is an exact model of a single valve of a *unio*, not excepting the muscular attachment pits and the hinges. It is flattened a trifle on the side to adapt it for standing firm as a useful domestic utensil. A cast in bronze would be no mean object of vertu.

Ranking with this exceptional excellence in prehistoric art must be placed a specimen from the same region, a fish-shaped dish or bowl. There are several in the collection representing fishes, but they are crude, like the bulk of this class of pottery. One only ranks high as an artistic piece of work. It represents a "pond fish," *pomotis*, lying on one side, the opening being in the opposite and uppermost side. The head is executed with great freedom and accuracy, and the whole is the handling of one having an artistic feeling far above the makers of most of the objects found in mounds. There is one specimen showing an attempt to model the conch shell or *cassis*, but it is child's play, comparatively. Others more or less rudely imitate the shapes of bears, beavers, toads, dogs, etc. Several specimens Mr. Terry was much puzzled by.

There was, evidently, a form resembling some animal with its mouth holding an object supported by two forepaws. Subsequently, others were found more perfect in de-

sign; and here was most plainly represented a beaver, with its wood-cutting or log between its teeth, and held up by its short fore-paws. This is a valuable confirmation of observations made by Mr. Morgan, of Rochester, who wrote concerning the beaver. He states that it is extremely difficult to get sight of the beaver while he works, as he is shy, and does all his labor in dark nights. The use of the short, seemingly inefficient fore-legs and paws of this animal has been a subject for speculation. Mr. Morgan once distinctly saw a beaver, just before daylight, after much laborious watching, swimming with a log supported by his fore-feet. The other work is mostly accomplished by the strong hind-feet, which, being webbed, are powerful propelling members in water. This rude piece of prehistoric pottery tells a story that a few years since would have been news to naturalists.

Several water-jars, resembling the South American patterns somewhat, are fashioned in the shape of toads. Similar shapes for mouth-pieces whistles, and rattles were in great repute with the people of Central America. Where a hollow log could be utilized, a fragment of clay was introduced and a rattle thus improvised. Whistles were made in various ways. Some were constructed on water-jars, so that steam issuing from boiling water caused a musical accompaniment.

The larger pots, such as are used for burial urns and for cooking, have a decoration often produced by very simple means. The clay is plastered on the inside of a basket wrought of osier or rushes; when baked the wood is burned away, and the outside of the pot retains a uniform impression of the basket-work. Some specimens have the imprint of finger-nails. Broken specimens of others show good imitations of fern leaves, or "brake," possibly produced by the imprint of the actual leaf.

The ingenuity of these peoples extended to all objects susceptible of use or ornament. A rare specimen of this collection, because the first observed, is a round plate cut from a large shell, upon which is carved, in low relief, with tolerable skill, a Greek cross. Another has the same, *intaglio*, with simple lines. The spiral inner portion of univalve shells, the *columella*, that portion which is left after all the thin plate is cut away, is found in considerable quantities, and was, probably, used in domestic ornamentation. Mother-of-pearl is introduced very effectively in many instances. A wholly new and surprising example of ornamentation is seen in numerous bone objects. They appear to be the hollow, long bones of some quadruped, cut and fashioned for tubes. The lips are finished with a smooth border, but all other portions are entirely paved with small disks of shell, each having a minute hole in the center. These disks are made fast by asphaltum. The effect is very pleasing. Some of the hard stone pestles have the same kind of ornamentation. A stone tube, several inches in length, is adopted as a musical instrument, with several "stops." This also has the shell disk ornamentation arranged in patterns. Some sharks' vertebræ are prettily decorated in the same manner.

Bone ornaments are numerous, from the same sources, on the coast of California. These, and the shell-disk objects, resemble very closely the work of modern Pacific islanders. There are many simple instruments in bone, including all conceivable forms for domestic uses. The bone and shell hooks for fishing are especially fine, the series showing a number in various stages of finish. Found with these are some remarkable flint drills, which were, no doubt, used for puncturing and cutting the delicate parts of shell and bone objects. Some sandstone implements appear to have been made for similar cutting uses. There are several tibias, or leg-bones, of some large quadruped, which are fitted as musical instruments, having "stops," and a larger opening at the wider end, which, placed in water, modifies the sound.

Among the stone objects, not already alluded to and not hitherto known, are certain cone-shaped tubes made of serpentine. These were evidently used for smoking. They resemble a very large, modern cigar-holder. Numerous stone pipes of more or less pretension in carving are among them. One interesting specimen is of the bulky order called calumet, representing a bird. Many forms of stone implements mystify by their peculiar forms; others have familiar shapes, yet, unless they are made for mere ornament, do not suggest a reason for the enormous outlay of labor which has evidently been bestowed on them. Among the last are several hard stones, cut very closely in the form of a fin-backed whale; certain parts are quite artistic in execution. A large metate, or corn-grinder, in volcanic scoria, exhibits considerable skill—as much as would to-day be expected from a stone-cutter. It has a rectangular form, about two feet by sixteen inches. The three square-shaped legs support it, the whole being of one piece of rock.

Large stone spear-heads are not unfrequently found in mounds and on the surface in all parts of our country. Seldom, however, have any been observed showing the methods used to fasten them to handles. Mr. Terry has several with the asphaltum yet adhering to the hilt end, and certain impressions upon this matter show plainly they have been made fast to handles. The collection of stone arrow-heads is exceptionally fine, the obsidian specimens especially so.

Connecticut being the native State of Mr. Terry, it is reasonable to look for due attention to the prehistoric remains of that section, and there is a rich display from there. Certain discoveries in Western States of great numbers of stone implements, precisely of one pattern and size, found buried "*en cache*," regularly set in rows, edges uppermost, have caused much speculation. Mr. Terry found in a *cache*, in Canton, Conn., 22 stone spear-heads of fine workmanship, all of the same material, size, and shape. This hints at stock in trade or a magazine of stone weapons, whereby our prehistoric worthies were armed with considerable uniformity, recalling the examples so common in Europe, of large numbers of bronze spear-heads, etc., of uniform pattern, being found in tumuli. Several polished axes and "celts," are finer than those usually found in New England. There is, however, evidence that objects of this character were bartered or captured from a distance. Geological or lithological knowledge determines this matter. A most interesting example of this is the result of a late discovery of mica quarries in North Carolina. Before this it was undetermined whence came the vast amount of mica that was found by Squier and Davis in Ohio mounds. Those quarries are thought to be the nearest deposits.

The diskoidal stones are most pleasing objects; showing great skill in carving. Some of these are beveled in such a manner as to roll in a spiral direction inward to a given point, and are, for that reason, supposed to have been used in games. In archives of very early explorers of this continent the larger diskoidal stones are mentioned as forming part of certain games. Of fanciful weapons, called, variously, "totem," "banner-stones," "butterfly-stones," etc., some excellent examples are here from Missouri mounds. It is interesting to notice that certain of these are always made from the same kind of stone—an indurated clay or metamorphic slate, having striæ, which, no doubt, attracted attention from its pretty aspect. Curiously enough, objects in this stone are found in all parts of the country between the two oceans. Unfinished specimens, showing the cores which are left after drilling with reeds, are instructive. A large series of these is here. A very beautiful "banner-stone," of the "butterfly" pattern, is in rose quartz. Three other specimens of this same shape and material are from different and distant localities.

Fine examples of stone hoes and spades, found in the mounds and graves, are in this collection. The latter are long, oblong-chipped flints, or chert, always showing the larger or lower end considerably polished through constant use in the soil. Like many other forms for domestic purposes, these have a finish that one would suppose entirely unnecessary. The stone pots for boiling water, and stone hoes for digging in the earth, might well be much less beautiful, and yet serviceable. We may, then, attribute considerable natural taste, as well as artistic skill, to these peoples of prehistoric times.

It is a well known fact that archæologists have never observed any example of casting in iron or copper attributable to the mound-builders or the contemporary races. Numerous copper implements are found, especially in the region of the great lakes. In some ancient mines of the Lake Superior region many stone implements have been found. At the Centennial Exhibition, in Philadelphia, a mass of copper was on view which measured over five feet in length, and stood two or three feet in height. This was entirely copper, and was exhibited on account of its showing, on all sides, marks of the prehistoric stone axes and hammers. Having no iron tools, these people beat the soft copper into ridges so thin that they could easily be broken off, when they formed them into rude implements—not by casting, as they did not have knowledge of the art, but by beating with stone hammers. Iron was yet a useless thing to them, but in some instances the red oxide of iron or hematite was utilized, as any other pebble or stone, from which they formed "celts" or axes. This oxide of iron is usually seen, when formed into implements, in small, toy-like hatchets. Mr. Terry has discovered several that measure about seven inches in length, and have the usual shape and finish of the average "celt," or ungrooved ax. Pieces of the red oxide of iron are used by savage tribes in painting their skin, the oxidized surface furnishing the red powder.

THE OILS AND OIL WELLS OF BURMAH.

AT a recent ordinary meeting of the Geological Society of Glasgow, Dr. James R. M. Robertson, of Renfrew, a well known mining explorer in distant parts of the world, read an interesting paper on the oils and the more salient geological features of those parts of Burmah over which petroleum or earth oils have been found, and giving an account of some investigations which he had personally superintended in connection with the existence and occurrence of those oils.

He first dealt with an outline description of the great range of country embraced by Burmah and the territories immediately surrounding it.

Besides mud volcanoes, which were scattered over Cheduba and Ramri, as also the Barongah Islands—three in number—petroleum had been known for ages to occur. In some parts along the coast gaseous hydro-carbon escaped under high water mark, and could be inflamed on coming to the surface. Occasionally, during violent eruptions of the mud volcanoes there were large quantities of inflammable gas emitted, which, in some recent instances, had caught fire, and had illuminated the country for many miles around. Those violent eruptions were always synchronous or simultaneous with earthquakes passing over adjoining countries. Similar emissions of gas had been observed in the mud volcanoes of Java, Baku (on the Caspian Sea), and near the Sea of Azof. When the volcanoes were in a quiescent state bubbles of gaseous hydrocarbons issued from the vent. In Pathar, in Assam, there was a certain hollow that contained many muddy pools in a state of constant activity which threw out white mud mixed with petroleum.

The petroleum of Cheduba, Ramri, and the Barongah Islands was of a light specific gravity, of a mahogany brown or brandy color, containing a very large proportion of burning oil, and almost no solid paraffin. Oils possessing the same physical properties and chemical composition were found in the Punjab and Beloochistan, in the vicinity of long dormant mud volcanoes, and on the shores of the Red Sea below Suez. On the western islands of Burmah the oil was collected in shallow holes or wells, and was periodically drawn off. In Cheduba and the Barongahs the holes were quite shallow, but in Ramri certain groups of wells had been sunk to a depth of from 20 to 30 ft. before reaching the stratum from which the oil was got.

As a rule, however, even in Ramri, they were mere surface pools. Only an insignificant quantity of oil was obtained in the pools or wells—ranging from two to five bottles per day. The wells were not evenly scattered over the surface of the ground, but were grouped together in those situations where the oil was yielded. So far as was yet known—and certainly the result of all the author's investigations had convinced him that, saving the appearance of the oil itself—there were no positive signs or indications by which an observing man could prognosticate or determine, or fix on sites as those likely to yield a supply of oil. The oleaginous spots were eminently capricious and partial, and were determined by causes as yet unknown. Dr. Robertson went on to relate that in the latter part of the year 1877, two English companies began the exploration of the Barongah islands for petroleum, convinced that the appearance of the hydrocarbons on the surface betrayed a deeper origin, and large reservoirs of oil in the depths, both companies resorted to boring. At the date of the author's arrival at Ackyab, the borehole had, in one case, reached a depth of 260 ft., having passed through successive beds of "chucky" sandstone and arenaceous shales or clays containing calcareous nodules. Some of the beds were supposed to smell faintly of oil. In the other case two pits, 30 ft. in diameter, had been sunk to a depth of 30 ft., and in the bottom of each a borehole had been sunk. On reaching a total depth of 68 ft. from the surface, and after piercing a firm bed of calcareous clay, the boreholes evidently struck a fissure containing pent up gases. On being tapped, the gases rushed up the bore hole with violence, and were followed by oil. About 500 gals. or so per day were obtained during the first week, after which the quantity diminished to insignificant proportions. That was the only instance within the author's knowledge in which oil in those regions had been struck by a borehole, and had risen to the surface. (It had been reported within the past few weeks that other flowing wells or bores had been tapped; but Dr. Robertson was doubtful of the accuracy of the report.) In the case of the shallow native holes referred to, the supply had existed for centuries without, it was affirmed, any apparent or appreciable diminution. The supply might be taken, in short, to represent the rate of elaboration, or the rate at which the formative process went on. In the case, however, of the slightly deeper wells, the yield which at first was greater than in the surface pools, was, as a rule, liable to diminish; and in all cases where the depth of the wells was affected by the prevailing temperature, or where they were within climate influences, the supply was intermittent—the yield in such cases being greatest just after the hot season and during the prevalence of the monsoon rains.

Dr. Robertson subsequently proceeded to speak of the eastern extremity of the oleaginous zone of rocks within which earth oils had been found. The country referred to was spoken of as being to the east of the Arrahan mountains, and as being wild and innocent of roads. It had not been surveyed with any degree of accuracy. Broadly considered, he regarded the rocks as belonging to the nummulitic or Lower Eocene age, and in parts as giving place to Miocene deposits.

The oil was contained in the porous sandstone or sand, as in a sponge, and from it when pierced the oil slowly exuded, not—as in the case of the western islands—as a thin mahogany colored liquid, but as a thick greenish colored liquid, containing a large percentage of solid paraffin, of pleasant smell, and entirely differing in physical and chemical properties from the product of the west coast. Its only point of resemblance lay in its being found under similar or almost similar conditions. There was a firm layer of arenaceous clay, containing calcareous patches, overlying and underlying the kabaas. In the author's opinion the clays were almost impervious to water, and when brought to the surface they were perfectly dry. That circumstance, combined with the different properties of the oil, and the fact that it was only found in the soft porous sand, early raised questions and speculations in his mind as to the origin of the product. At this stage Dr. Robertson discussed at some length the alleged sources of the oil, both from the geological and chemical points of view; but none of the explanations that had been given were satisfactory to him. Speaking again of the wells near the Burman village previously mentioned, he said that after the first monsoon rains had fallen the yield of oil from the top kabaa greatly increased in amount, and the increase was not accompanied by any increase of water. The amount of the increase varied in the different wells from three to six times more than that drawn during the dry overpowering heat of the hottest months.

For the purpose of obtaining some information that might be turned to good account in his investigations in Lower Burmah he determined to proceed to Upper Burmah, and trust to the fates and good luck to be enabled to inspect the King's Well, which for centuries had yielded very large quantities of oil. He described the voyage up the river Irawaddy till he came to Yeynan Choung—a name which signifies earth oil creek, the shipping place of the oil drawn from King Theebaw's wells. As the steamer approached the place the smell of petroleum was perceived to fill the air. A fleet of cargo boats had it in bulk, and acres of great earthen jars containing it lined the beach. The wells were situated a few miles inland, and reached by an almost impassable tract. Beyond the limited but extremely picturesque patch of fertility surrounding the town there was a region of perfect sterility stretching as far as the eye could reach. Here they lived a rough and ever watchful life within the high stockade of the Indian Mohammedan who farmed from the king the whole produce of the wells. At the river the strata had a strike approaching south-east by north-west, the beds at first lying irregularly, but generally at a high angle, and sometimes in faulty ground being tilted on edge. The rocks seemed to be non-fossiliferous, and were composed of soft variegated sandstone, traversed by strings of talc and calc spar, and inclosing accessory blocks of hard flinty masses of water-worn sandstones or gray sandy clays. As the author and party proceeded inland the rocks gradually approached the horizontal, and by and by they arrived at a point from which they could look down upon the famous Tongune oil wells "of the master of many white elephants and the "great king of righteousness." There were about 800 wells occupying the top of a broad ridge between two parallel ravines, the space over which they were scattered being oblong and not exceeding 500 acres in extent. Why the area of the oil-bearing rocks should be so strictly defined as was seen to be the case was not very clear.

According to the natives no oil had ever been found beyond the lines of the two ravines. To the east and west the ravines were about 60 ft. deep, and had all but perpendicular sides. Wells were sunk all along the inner cliffs that yielded large quantities of oil. On the opposite cliffs, at about fifty or sixty feet from the working wells, there were seen the remains of several old wells, which had been sunk to the kabaa, but they gave out no oil. Not a single well existed beyond the line of the choungs or ravines. To the north and south a few abandoned wells were also seen on the surface, which had been sunk in the expectation of proving a continuation of the oil kabaa. They did prove its continuity, but it was thinner and of harder consistency, and instead of oil it gave off water. A careful examination of the rocks exposed in the ravines disclosed the fact that the course of the arbitrary line that determined the oil yielding kabaa almost exactly corresponded with the course of a very slight anticlinal, while to the south the change of dip marked the boundary in that direction.

Over the uneven surface of about a square mile under which the deposit extended, fully 1,000 wells had been sunk, of which about 800 were capable of yielding oil, although at the present moment, from the lessened demand in British Burmah, consequent on the large importation of the American product, and from the state of disrepair into which many of the wells had fallen, there were not more than 280 wells being worked. Roughly speaking, the largest proportion of the wells were grouped along the margins of the ravines. It was believed (and the author thought the natives were justified in believing) that if all the abandoned wells were cleaned out and resunk they would again become oil yielding wells. That, however, even with appliances for producing ventilation, would be a difficult operation, as from the abundant gases given off no lights could with safety approach a yielding well. Sinking and such like operations were conducted in total darkness, a workman not being able to remain in the bottom more than from two to five minutes, and even then he was drawn up limp and totally exhausted. Within the oil district the working wells did not yield a drop of water; a few yards beyond the arbitrary boundary line, however, wells sunk to the same position gave off an abundant supply of water, which, as a rule, was charged with sulphureted hydrogen gas.

The oil yielding stratum had a thickness of about 5 ft.,

and in its composition it was loose and incoherent. It was highly charged with oil, which oozed out whenever a fresh piece was placed on the ground. A few irregular pockets of lignite were got in one or two of the wells, in a sandstone lying many feet above the kabaa. When the oil kabaa was pierced, gas and oil issued freely, but with no force or pressure, the oil exuding as water did from a freshly charged sponge. It never rose more than a few feet. If a group of wells closely placed together were worked simultaneously, the yield from each well was appreciably less than if one-half of them were stopped. For that reason the drawing wells were now spaced about 40 yards apart. The production varied from 5 to 1,000 vis per day per well—a vis being equal to fully one-third of a gallon; it might therefore be said that the yield ranged from 2 to 400 gallons per day. Some wells yielded from 500 to 700 gallons per day for the first three years, and yet others, by which they were surrounded, did not give one-fourth of that quantity. One well was specially pointed out to the author that had yielded 700 gallons per day for a number of years, after which the supply diminished gradually until it reached 180 gallons, and for the last eighteen years it had yielded that quantity daily. The depth of the wells varied with the surface level, and with the dip or rise of the strata. In some places the average depth would be about 320 ft., in others upwards of 400 ft., and in others it decreased to 200 ft., and even to 120 ft. How one well, surrounded by twenty or thirty others, should give five or six times more oil than those adjoining would, the author thought, only be satisfactorily explained when a clew had been discovered to account reasonably for the production of the oil itself. There were three qualities of oil obtained from the wells: (1) Yeyuan Ghee, or butter of oil; (2) Umbawn; (3) Kyathee. They were all of a dark green color, thick and viscid in consistency, and becoming almost solid at a temperature of 60° Fahr. or under. The odor was pleasant and not strong, and the specific gravity was about 0·810. Newly drawn oil had a temperature of about 88°, or 26° under the temperature of the air in the shade at the time of the author's visit to the wells. It differed from the American petroleum, and that of the west coast in containing a very large proportion of solid paraffin. About 71 per cent. of the whole was burning oil, the flashing point of which was about 20° higher than that of the American oil, while in every respect it was a superior and more valuable product. At the time of Dr. Robertson's visit—sixteen months ago—the quantity of oil drawn from the wells under notice was 6,000 gallons per day, which was said to be scarcely one-half of what the wells could produce.

Dr. Robertson subsequently described another oil yielding district, called Bhaema, about three miles to the south of the Tongune wells, and where, from very ancient times, oil had been obtained under precisely similar conditions. There were upwards of 200 wells in the district, which was shown to be quite as peculiar in its physical characters as that previously noticed. About eighty were working at the time of the author's visit, and the total yield was about 2,200 gallons per day, or an average of 28 gallons per day for each well. Further up the river—about thirty miles, and about ten miles inland—there was another small group of wells, the product of which was generally similar in character to that of the oil found in the western islands formerly referred to. Dr. Robertson did not visit the district, as by this time his movements were looked upon with a certain amount of suspicion. He again returned to the consideration of the conditions under which such oils had been produced in various parts of the world, and in conclusion he suggested a number of knotty points which required to be solved before any sufficiently satisfactory explanation of the origin of earth oils could be arrived at.

THE VOLCANIC ERUPTION IN DOMINICA.

On Sunday, January 4, shortly after eleven o'clock in the morning, a volcanic eruption occurred in the Grande Soufrière district of Dominica. This district is situated near to the center of the southern third of the island; and before the late eruption its volcanic energy was manifested by the action of four solfataras and by the Boiling Lake. During the morning of January 4 the weather in the town of Roseau, the capital of the island, was cool and showery; but shortly before eleven o'clock the sky became overcast and heavy rain began to fall, accompanied with thunder and lightning. Soon afterward the sky darkened; the rain poured in torrents; a powerful odor of sulphureted hydrogen pervaded the atmosphere; the lightning increased in vividness; and thunder of a peculiar sound, and without the usual reverberation, crashed for several minutes, with intermissions of so short a duration as to be scarcely recognizable. After the lapse of about five minutes the darkness began to lift, and it was then seen that the rain was bringing down volcanic ash of a light grayish color and metallic luster. The ash fell for about nine minutes, covering the ground to the extent of a quarter of an inch, and during the time everything had a dull leaden aspect, while the mud rolled off the houses and the leaves of the trees like big globules of partially oxidized mercury. During the time the ash was falling I noted that the barometer indicated a pressure of 30·10 inches, and a few hours afterward the mercury fell to 29·96 inches. The Roseau River, which rises near to the volcanic district, became a raging torrent, flooding the land through which it passed and creating great destruction; its water became of an opaque white color, and even now, more than three weeks after the eruption, the white color remains, though in a lesser degree. It is worthy of notice that the greater body of water came from the vicinity of the eruption, for the lower tributaries of the Roseau River were very little swollen.

The scene of the eruption is about eight miles east from Roseau, and the volcanic ash was blown to the west by the trade wind in a narrow belt about one and a half miles wide. There is, unfortunately, no means of ascertaining the extreme limit of this belt; but a small vessel, which was about four miles out at sea at the time of the eruption, experienced a shower of ash similar in every respect to that which fell in Roseau. The area, then, over which the ash fell, must have been at least twenty square miles.

On the 12th of January I visited the Soufrière district, and found that a volcano had opened up about a mile to the southwest of the Boiling Lake. The Grande Soufrière lies in the depth of the primeval forest which covers the greater part of Dominica, so that no loss of life occurred; but for a considerable distance beyond the crater the trees have been destroyed, and the earth is covered several feet deep in some places with volcanic *débris*. Here and there stumps of blasted trees sticking up a few inches or a few feet from the gray ash give a striking evidence of the force of the explosion. Most of these stumps have been quite shattered by the ejecta, and in many were found embedded large pieces of trachytic rock. I did not observe any traces of fire, but, on scraping away the ash from the ground at some distance from the lip of the crater, large splinters of wood and a few bleached leaves were discovered. Beyond this zone of desolation the forest has been destroyed to a great extent by a whirlwind, which appears to have occurred just before the eruption. Branches of trees, broken and twisted off from the parent stem, have fallen to the ground, and by their weight have crushed down all the forest undergrowth. In spite of the heavy rains, which had been almost continuous since the time of the eruption, I found the ash still tenaciously clinging to the leaves and the trunks and the branches of the trees. The swollen streams which run through the ravines radiating from the volcanic district were in many places dammed up with large pieces of sulphur and pumice and with splinters of wood. On reaching the lip of the crater, which was a work of some difficulty on account of the depth of the ash, the bottom was seen about 600 feet below. This appeared to be cooling down, for although commotions were observed in several places, there was no flame or glow visible. Here and there columns of aqueous vapor ascended and widened out into clouds before reaching the lip, so that the bottom of the crater could only be seen at intervals. The crater is ovoid, with its long axis running in a direction from west-southwest to east-northeast, and the lowest part of the lip, as measured by the aneroid barometer, is 2,615 feet above the level of the sea. At the northeastern extremity there is a break in the side of the crater, and through this a quantity of volcanic mud poured into the Point Mulatre River, which flows toward the eastern side of the island; it would appear that an enormous quantity of the gray mud was thrown out, for it is stated that at one time the bed of the river was nearly filled up, but since the eruption most of the mud has been carried out to sea.

Large masses of pumice and sulphur are seen in the vicinity of the crater, and I picked up near to the lip pieces of feldspar and porphyry. Rocks containing augite are found in abundance, and the solid ejecta lying about in all directions are composed for the most part of gray trachyte, containing a large proportion of iron pyrites. Were these trachytic rocks pulverized they would form, with the addition of sulphur, a sand similar in appearance to that which fell in Roseau at the time of the eruption.

Strictly speaking, a new crater has not formed, for the eruption was only the breaking into activity of an old volcano. The Grande Soufrière district formerly included four solfataras and the Boiling Lake, and the most active of these solfataras was situated in the crater of the volcano which has again become active. With the exception of a part of the bottom and southern side occupied by the Soufrière—as a solfatara is called in the West Indies—the crater was clothed with trees, many of which were of large size and considerable age; and a stream of strongly ferruginous water, rising at its southwestern extremity, ran through the ovoid basin and found an exit at the break of the northeastern side. The path to the Boiling Lake passed through the crater, and the north bank of the chalybeate stream—which has now entirely disappeared—was the usual place selected for an encampment by those visiting the lake. No earthquake was experienced at the time of the eruption; and beyond the peculiar thunder there were no sounds, similar to the booming of cannon, which are usually mentioned as concomitants of all manifestations of volcanic energy. It is also to be noticed that there was no flow of lava, and, on my visit to the volcano, I found no trace of this usual educt of an eruption. It may be that the resistance to the volcanic force was too small to cause much tremulation except in the immediate vicinity; and the surrounding country is of so rugged and broken a nature—dislocated rocks, and sharp ridges alternating with deep ravines—that a seismic wave would be propagated with difficulty.

The ash and sand which fell in Roseau was similar in many respects to that ejected from Tomboro in April, 1815, for on that occasion the commander of the H. E. I. C. cruiser Benares, reported concerning the ash which fell at Macassar: "though an impalpable powder or dust when it fell, it was, when compressed, of considerable weight; a pint measure of it weighed twelve ounces and three-quarters; it was perfectly tasteless, and did not affect the eyes with painful sensation; had a faint burnt smell, but nothing like sulphur; when mixed with water it formed a tenacious mud, difficult to be washed off."* The ash which fell in Roseau was heavier, for a pint measure of it without compression weighed twenty-ounces and fifteen drachms; this heaviness may, however, be accounted for by the large proportion of iron pyrites, and the presence of this mineral was the cause of the metallic glistening first noticed when the ash fell.

M. Bert, a resident in Roseau, has made a qualitative analysis of the ash, and he informs me that he found the following bodies: Ferric sulphide, magnesia, potash, soda, silicon, sulphur, carbon, oxides of iron, lead, and alumina. M. Bert also found traces of other bodies, but their proportion was so small that he was unable to determine their exact nature with the means at his disposal.—*H. A. Alford Nicholls, in Nature.*

THE ELEPHANT IN AFGHANISTAN.

The familiar camp game, "The tug of war," in which one squad of men match their strength and weight against another in pulling, was varied during the Afghan campaign by matching men against an elephant, as shown in the opposite illustration. Doubtless the elephant entered into the sport as heartily as the men; and with an animal weighing four or five tons, and possessed of great strength for its size, the task of outpulling him must have been no easy one.

In carrying on military operations in a rough and comparatively roadless country like Afghanistan, the elephant has been found especially serviceable. This not so much on account of his great strength and endurance, as because of the peculiar structure of his legs, which enables him to surmount with ease declivities quite inaccessible to the horse. Strange as it may seem for so clumsy an animal, the elephant can not only travel where a horse cannot, but is able to haul heavy loads, such as cannon, baggage wagons and the like, over hills and across ravines where horses would be entirely useless. A strong animal can travel fifty miles a day with a burden weighing a ton; and in dragging heavy artillery over difficult places the elephant supplements his great strength with a sagacity which makes him an extremely valuable aid in broken and mountainous regions.

* "Memoir of Sir Thomas Stamford Raffles, F.R.S." London, 1830, p. 246.

WHERE DID THE ISRAELITES CROSS THE RED SEA?

To the Editor of the Scientific American:

From the short article with the above heading in your December monthly part (page 354), I perceive with some surprise that the thoroughly satisfactory solution of the long-vexed question, published some years since in Europe, has not yet become generally known in the United States. Permit me to give, very much condensed, the main points of an essay on the subject by the learned Professor Graetz, of Breslau—an essay equally remarkable for the profound learning and for the keen sagacity which it displays.

I. As the result of a discussion of the conflicting statements and views of the principal ancient and modern authorities—Herodotus, Strabo, the "Itinerarium Antonini," Robinson, Lepsius, Bunsen, Brugsch—he establishes beyond dispute that, in the age of Moses, the canal connecting the Nile with the Red Sea already existed and was navigated. About a thousand years later, Herodotus (II., 158) says: "Its length is a voyage of four days, and in width it was dug so that two triremes might sail rowed abreast. The water is drawn into it from the Nile, and it enters it a little above the city of Bubastis, reaches to the Red Sea, and terminates at the Arabian city, Patumos." In Cary's translation, for the words "terminates at," one reads "passes near." The first reading is based on an emendation of the Greek text, by Prof. Wesseley, confirmed by two ancient manuscripts.

II. Patumos was the port built at the eastern end of the canal for the accommodation of traffic; and was situated on one of the most northerly of the lakes through which Lesseps' canal now passes. These lakes, then, were, in those ages, parts of an arm of the Red Sea. How broad and deep this must have been, may be judged from the fact that the accumulating sands of 3,000 years, which have obliterated the canal, have still left so much of it in the form of lakes.

III. The Israelites departed from Rameses, passed north of the lakes to Succoth, and thence to Etham, "which is in the edge of the wilderness" (Numbers xxxiii. 3, 5, 6, Exodus xiii. 20). It had become clear to Moses that, with his multitude of just liberated slaves, encumbered with their wives and children, their flocks and herds, it would be folly to attempt an invasion of Canaan, filled with warlike races accustomed to military operations; and he determined to take the other route through Midian, a country in which he had passed many years, of which his wife was a native, and where her father still lived. Why not, then, simply change his course from the northeast to the south and southeast, and thus avoid the Red Sea altogether? The answer is obvious. The want of water. He had no other course than to retrace his steps. As there was then no suspicion (as appears from Exodus xiv. 10) that Pharaoh had again changed his mind and determined to pursue him, he returned to the west side of the present lakes, and encamped "before Pi-hahiroth, . . . over against Baal-zephon, . . . by the sea" (see Ex. xiv. 2). It is obvious, also, that his intention was to take a new departure thence: doubtless by the route which he had himself in other years traversed.

IV. It remains to identify Pi-hahiroth:

(1) In Exodus i. 11, we read: "And they (the Hebrews) built for Pharaoh treasure cities, Pithom and Raamses." There is here a mistranslation; they were not "treasure" cities, in our sense, but cities of magazines for the storage of the king's grain; and both were on the canal, there built to facilitate the export of breadstuffs.

(2) Baal-zephon (or Typhon) was not the name of a place—a mistake which has caused infinite trouble and annoyance to the commentators—it was that statue of which Plutarch speaks: "In Hermopolis they show a statue of Typhon, a hippopotamus, on whose back is a sparrowhawk fighting with a snake. Typhon is signified by the hippopotamus." Hermopolis, in this passage, is an error of the ancient transcribers for Heroopolis. This is also the opinion of Bunsen, who remarks: "Typhon belongs to the desert: he signifies the destructive power of aridity."

(3) Pi (town, city) ha-chiroth, or Hiroth, is simply a Hebrew form of the name, written "Heroopolis" by the Greeks, the city of the god Her or Hero. The Patumos of Herodotus was the Pithom of Exodus i. 11, and Pi-hahiroth, therefore, is identical with Pithom, the port built by the Hebrews themselves at the junction of the canal and the long northern arm of the Red Sea.

(4) I do not know that the precise site of this port has been discovered, but it must have been at the most northerly point possible, where an adequate harbor could be constructed; for, first, owing to the character of the country, the labor and expense of constructing the canal would be lessened; and, secondly, the farther north, the more convenient for the caravan traffic with Syria. This point does not appear to have been upon the more northerly of the lakes through which Lesseps' canal now passes; but upon the deep water, south of the shoals, which then lay between this and that into which the ancient canal entered.

V. It is obvious that the Hebrews had encamped on the north side of the town; both because at the ends of their toilsome march they would not immediately undertake the laborious task of crossing the canal, and because the statue of Baal-zephon—the god of the desert—would naturally be placed somewhere on the great northerly caravan road leading thither. It is also self-evident, that, as the Egyptian army was in pursuit of the Hebrews, its route was the road north of the canal and near to it, because armies and caravans depended upon it for water.

VI. Combining these suggestions with the facts ascertained by Prof. Graetz and with the words of Exodus xiv. 2, bearing in mind, also, that no thought of danger from Pharaoh troubled the Children of Israel—he took them by surprise (see v. 16)—and that "no pent up Utica" would suffice for the camping place of 600,000 people with flocks and herds, the situation is perfectly clear.

It was at the end of March, a season, in these regions, like the summer of northern climes, save for the cool, high winds from the distant mountain ranges. The vast multitude was encamped far and wide over the sandy plains in the angle formed by the canal and the northerly end of the arm of the sea. Thousands were busy in refreshing the flocks and herds from the sweet waters of the canal; others doubtless were adding to "the spoils of the Egyptians," by "conveying, the wise it call," supplies from the royal granaries in the town. The leaders were in council, discussing routes and supplies for the advance into Midian. There was no thought of danger. When, therefore, the cry was raised that Pharaoh was approaching, the Hebrews may well have

BRITISH MILITARY AMUSEMENTS IN AFGHANISTAN: THE "TUG OF WAR" IN THE CAMP AT GUNDAMUK.

been "sore afraid." Entrapped as they were, there was but one point in their favor, namely, that the distance at which across that level country the enemy could be seen would give them ample time to prepare for moving, if they only knew whither, before they could be attacked.

Is it not possible that, after the late experience of the Hebrews and in their present frame of mind, Moses would have found it impossible to carry out his purposes, and the whole current of Jewish history have been changed, if not annihilated, but for this pursuit by Pharaoh? The question opens a curious subject for speculation, but one out of place here.

At all events, before the Egyptians could be upon them, a way was opening by which these shoals, which had determined the position of the town built by the fathers, should become the salvation of their descendants

To one who has observed the action of the winds upon the shallow bays of the Northern Adriatic, the ordinary tides of which are but two or three feet—in increasing the ebb and flow of spring tides to a difference of seven or eight, the effect of the strong northeast wind during the night that followed, in laying bare the shoals in front of the Hebrew camp, is perfectly comprehensible and credible. Besides, every reader of this, who lives upon the sea coast or on the shore of any broad sheet of water, will be able from personal observation to know, also, that the profuse vapors, arising from the waters warmed by the sun in front of the fugitives, being carried inland by the same cool wind, would retain their invisibility for a considerable distance before condensation, even by the coolness of the night; so then, in truth, under the circumstances detailed in Exodus xiv., the leaders of Israel might depend upon having a clear, bright day for their movements, while their pursuers would have their military operations prevented by the density of the fog*—even if they had dreamed of any necessity for haste.

Thus, undiscovered by Pharaoh, the multitude on that bright morning began its march across the sands, and he must be a bold skeptic, indeed, who, in the light of Professor Graetz's discoveries and reasonings, shall hereafter doubt that this march was successfully accomplished.

The ancient chronicler, of course, represents the confidence of the sagacious Jewish leader as derived from personal communications of the Most High; but the query *will* arise: Had he not learned by observation or report the effects produced here by a strong northeast wind?

That the "waters stood upright as a heap," as we read in the song of triumph, is evidently but a poetic exaggeration of the fact mentioned in the prose account, that the deep waters above and below the shoals were *as* a wall to the fugitives, protecting their flanks.

That the volume and force of the returning waters were sufficient to overwhelm the whole Egyptian army is certainly hardly credible. But if the shoals were such as are elsewhere known, which, when drained, are solid and firm, but become by saturation dangerous quicksands, incredulity vanishes. That such was the case may be inferred from some of the minor circumstances recorded.

The best condensed statement of the old hypothesis that I have seen is in Baedeker's Handbuch for Egypt. This places Pi-hahiroth down near Suez; assumes Baal-zephon to have been the name of a range of hills on which sacrifices were offered to the north wind; and takes for granted that the Israelites performed an unbroken march of some fifty or sixty miles. Read the many descriptions of such marches by well mounted rangers on our great western waterless plains, and then judge of the possibility of thousands of old men and women, of young children, of flocks and herds, accomplishing this distance over the rocks and stones and burning sands of the desert!

A. W. THAYER.

TRIESTE, February, 1880.

JAPANESE LADY SEIZED BY AN OCTOPUS.

By the kindness of my friend, Mr. Bartlett, I have been enabled to examine a most beautiful Japanese carving in ivory, said to be 150 years old, and called by the Japanese *net suke* or *togle*. These togles are handed down from one generation to the next, and they record any remarkable event that happens to any member of a family. This carving is an inch and a half long, and about as big as a walnut. It represents a lady in a quasi-leaning attitude, and at first sight it is difficult to perceive what she is doing; but after a while the details come out magnificently. The unfortunate lady has been seized by an octopus when bathing—for the lady wears a bathing dress. One extended arm of the octopus is in the act of coiling round the lady's neck, and she is endeavoring to pull it off with her right hand; another arm of the sea monster is entwined round the left wrist, while the hand is fiercely tearing at the mouth of the brute. The other arms of the octopus are twined round, grasping the lady's body and waist—in fact, her position reminds one very much of Laocoon in the celebrated statue of the snakes seizing him and his two sons. The sucking disks of the octopus are carved exactly as they are in nature, and the color of the body of the creature, together with the formidable aspect of the eye, are wonderfully represented. The face of this Japanese lady is most admirably done; it expresses the utmost terror and alarm, and possibly may be a portrait. So carefully is the carving executed that the lady's white teeth can be seen between her lips. The hair is a perfect gem of work; it is jet black, extended down the back, and tied at the end in a knot; in fact it is so well done that I can hardly bring myself to think that it is not real hair, fastened on in some most ingenious manner; but by examining it under a powerful magnifying glass I find it is not so—it is the result of extraordinary cleverness in carving. The back of the little white comb fixed into the thick of the black hair adds to the effect of this magnificent carving of the hair. I congratulate Mr. Bartlett on the acquisition of this most beautiful curiosity. There is an inscription in Japanese characters on the underneath part of the carving, and Mr. Bartlett and myself would of course only be too glad to get this translated.—*Frank Buckland, in Land and Water.*

ENDLESS CHAIN MINE RAILWAY AT FILLOLS.

The iron mines at Fillols, in the Canigou region, Eastern Pyrenees, are situated at a high elevation, from which the minerals are conveyed by gravitation, in small wagons on a double line of railway, with endless chains. The system extends over a distance of five miles in direct length, between the highest point, called Salvé, and the station at Prades. The undulations of the surface are followed, for the most part, though here and there holes are filled up and humps are removed. The railway consists of seven inclined planes, on which two lines of way are laid to a gauge of 21½ inches between the centers of the rails. The rails are of Bessemer steel, 14 lb. per yard, fish-jointed, and laid on transverse sleepers, 30 inches apart. The difference of level at the mine and Prades Station amounts to 984 feet. The inclines, direct and reverse, vary from a level to 23 per cent., or nearly 1 in 4; they are connected by short pieces of level line. A directing pulley is placed at the end of each incline, and the system is automatic, and the loaded wagons, descending by gravitation, draw up the empty wagons. Each wagon weighs 500 lb. and carries a load of one-half ton. The speed is limited to 3·35 miles per hour, at which rate 300,000 tons per year can be transported. The wagons are controlled by means of four brakes with return pulleys.

The chains consist of ring-links, and weigh from 8 lb. to 20 lb. per yard, according to the maximum degree of tension on the different planes. The chain is supported on the wagons, and is attached to each wagon by a fork, between the sides of which one of the links enters. The chain is thus entirely supported by the wagons, and is suspended or floated (*chaine flottante*). The loaded wagons leave the chain at a distance of a few yards before the pulley, which is raised sufficiently high to lift the chain out of the fork and arrive quietly on tables. The wagons are pushed on down a slight incline to take the next length of chain, or, if it be removed at this platform, are turned aside and replaced by empty wagons.

The first cost of the floating chain system of transport amounted to £1,276 per mile. The cost for transport varied from ¾d. to 2¼d. per ton conveyed per mile. The cost for the whole distance, five miles, taken at 2¼d. per mile, amounts to 1s. 3d. per ton; while formerly the cost for conveyance by oxen amounted to 3s. 3d. per ton.

NEW RANGE-FINDER.

The little instrument which we illustrate below is the invention of Major Weldon, of the Madras Staff Corps. Its construction, as will be seen from the figures, is extremely simple, consisting of two reflectors, fixed like those of an optical square, each being adjusted to show an angle of 88° 34′ 3″.

Fig. 1 is a side elevation, Fig. 2 a front elevation, and Fig 3 a sectional plan of the instrument.

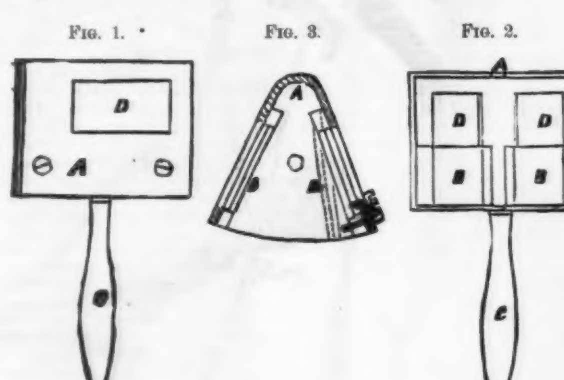
In these figures, A is a metal case, open on one side, in which two reflectors, B, B, are secured and adjusted; C is the handle for holding the instrument in front of the eye; D, D are openings in the metal case above each of the reflectors, through which objects in front of the observer can be viewed direct. In Fig. 3 one of the reflectors is shown as adjusted to a different angle by means of the screws in one side of the case of the instrument.

When using the instrument, it is to be held with the open side toward the eye, but slightly turned in the direction of the object to be reflected, so that on looking into the instrument only one reflector is visible, in which will be seen objects to the right or left of the observer. To determine an angle between any two objects, one in front, viewed directly through the opening above the reflector, and the other on the right, seen in the reflector, it will be necessary to move to the right or left, until the reflected object is seen to coincide with the object viewed directly. Slightly tilting the instrument will enable an apparent contact of both objects to be made when the angle is correctly determined. In measuring distances, this operation is called "angle-finding." To make an angle with a given line and a distant object, it will be necessary to move backward or forward along that line, until the two points that determined it are seen to coincide with the object. In measuring distances, this is called "base-finding." By this instrument it is shown that in an isosceles triangle, the base angles of which are 88° 34′ 3″, the base is to the side as 1 to 20; so that in range-finding, when, by means of an angle-glass or prism, set to 88° 34′ 3″, you find the length of base proportional to the sides of the isosceles triangle formed by a distant object and the extremities of the base, it is only necessary to multiply that length of base by 20, in order to find the distance of the object. The important point consists in using two fixed and known angles—or rather three known angles—in measuring distances, instead of one known angle and one known side or base, which usually entails complicated mechanism to measure the other angle, with corresponding liability to derangement and inaccuracy in manipulation, which is the great drawback of all other methods. The advantages of this system of range-finding consist not only in the fact that the angles are permanently fixed, thus affording the simplest form of instrument, but that they are fixed at such an angle as enables a difference of, say, 20 yards of distance to be readily appreciated by the eye of the observer; in other words, it insures that the base shall always subtend an angle of not less than 2° 51′ 54″, or the least that can be trusted to give a satisfactory result. A distance of 3,000 yards can be measured by this method with the same accuracy as a distance of 300 yards, the bases of each being proportional to the distance. Thus, the base for 3,000 yards would be 150 yards, and for 300 it would be 15 yards, no more nor less than is actually necessary to insure accuracy. 88° 34′ 3″ is mentioned as being the most convenient angle for this system, giving, as it does, a base of 1 in 20; still, it is not necessary that that proportion be observed; for instance, the base angles, being fixed at 87° 8′ 30″, would give a base of 1 in 10, and so forth. The principal point to bear in mind is that the two base angles, whatever their value may be, are fixed and known beforehand, the base only being variable and proportional to the distance.

In order to find the range with two men, No. 1 goes to the right and finds the angle, while No. 2 goes to the left and finds the base as follows: The two men stand facing the object, No. 1 on the right and No. 2 on the left; they will carefully note the object and select some prominent point on it to be observed in the angle-glass. They will then turn outward and note the particular spot on the ground in front of each that coincides with the reflected object, and march straight toward that spot until they reach the estimated length of base.

They now turn inward, and No. 2 stands steady while No. 1 makes an angle with him and the object; and when that is effected he stands steady. No. 2 now sees in the angle-glass whether the reflected object falls on the right or left of No. 1; if on the right, No. 2 must retire, to increase his distance from No. 1; if on the left, he must advance, to lessen his distance. After each move, No. 2 will halt and stand steady for No. 1 to make a fresh angle. In this manner Nos. 1 and 2 will alternately move and halt until they get the object fairly reflected on to each other. The distance between them is then measured to determine the range of the object; this can be done, either by pacing, or by a line of thin twine wound on a reel, and marked off and numbered at every five yards, representing so many hundred yards of range. To find the range single-handed, the observer plants a picket where he stands, or at any convenient spot, and goes to the right with another picket, having ascertained the direction in which he should go, as before explained; he then faces No. 1 picket, and moves to the right or left until he reflects the object on to No. 1 picket, when he marks the spot with No. 2 picket, and, having secured the end of the line close to it, runs out the line in the direction of No. 1, and beyond it on the line of both pickets, until he sees the object fairly reflected on to both pickets; the range of the object is then read off the line. To adjust the instrument, the simplest way is to lay out the required angle with a theodolite or sextant, and make the angle-glass agree with that angle. But, when an angle of 88° 34′ 3″ cannot be determined beforehand, it will be necessary to measure carefully with a chain a certain distance, say, 1,000 yards, from some well-defined object, such as a spire or a flag-staff, and then with a base of $\frac{1}{20}$th that distance (50 yards) mark the angle made by the angle-glass with the picket at the end of the measured line. The observer then goes to the picket marking the end of the line, and, if the angle-glass is in adjustment, he will see the spire or flag-staff reflected on the other end of the base. If the reflection does not fall on the other end of the base, the observer must advance or retire until the object is seen to coincide with the base line, and adjust the instrument to half the difference between the true length of base and that shown by the angle-glass.

FIG. 1. FIG. 3. FIG. 2.



IMPROVED RANGE FINDER.

PURIFICATION OF SMOKE.

The really objectionable portions of the smoke from factory chimneys consist, not of the mere particles of soot, but of the gaseous sulphur compounds that result from the combustion of the commercial qualities of coal. An apparatus, invented by Messrs. Johnson and Hobbs, and made by Mr. B. Goodfellow, engineer, of Hyde, designed for washing smoke, with the object of removing soot and the injurious gases, is now before the public, and many successful trials have recently been made with it.

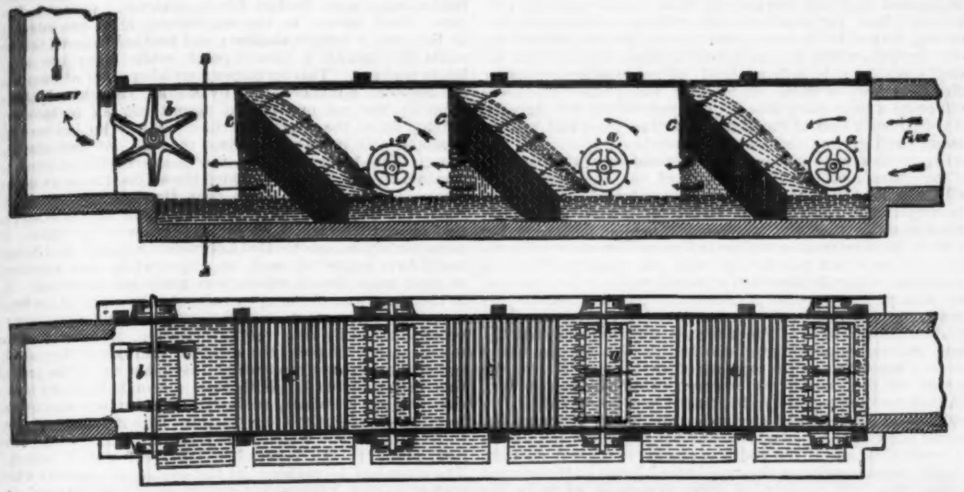
The system is based upon the well-known chemical fact that solutions of certain substances, or even water alone, have the property of absorbing gaseous compounds of sulphur, and as carried out in the apparatus the smoke is at the same time actually washed almost absolutely free from soot and blacks.

Referring to illustrations opposite, the upper is a sectional elevation of the smoke washer, and the lower a sectional plan. It will be seen that the arrangement consists of an enlargement of the flue, made of strong timbers, put together so as to be quite air-tight. The gases pass through it on their way to the chimney after leaving the economizer, should there be one in connection with the boilers. The bottom of the casing is a water-tight pit or cistern, and in the interior are erected wooden screens, *c c c*, the timbers in them being disposed so as to leave tortuous vertical passages. In front of the screens are dash wheels, *a a a*, the blades in which dip into the surface of water contained in the pit. The common tall chimney for creating the draught may be dispensed with, a sufficient current of air through the furnaces being obtained by the fan, *b*, a small chimney being all that is necessary to carry away the purified smoke. The dash wheels make about 200, and the fan 400, revolutions per minute. From actual experience it has been found that the machine we illustrate, with three dash wheels and one fan, is sufficient for four or five ordinary Lancashire boilers, and requires for driving it about 2½ nominal horse-power. The action of the contrivance is exceedingly simple: the tank is filled with water mixed with lime, and when the machine is set to work

* The escape of the remains of Washington's army from Long Island at the end of August, 1776, was rendered possible by precisely such a fog, caused by the same natural means.

it is projected in the form of spray by the dash wheels upon the screens, *c c c*; at the same time the fan, *b*, draws the products of combustion through the chamber and the passages in the screen. In this way every particle of the smoke is acted upon by the liquid, with the result that, when lime is present, the sulphurous gases are totally absorbed, and the blacks washed out and retained in the tank. We should say that were water alone used, by the absorption of sulphuric acid gas it would in time become very acid, and would act corrosively upon any ironwork present; in fact, in the first machines, where the timbers were held together by angle-irons, the latter were almost completely destroyed. By using lime the acid is neutralized, and does not therefore thus act detrimentally. Furthermore, iron work is avoided to the greatest possible extent in the apparatus.

At Mr. Goodfellow's works, one of these machines is worked in connection with a pair of boilers. By the aid of dampers and a junction in the flue the smoke could be sent



APPARATUS FOR WASHING SMOKE.

at will up the ordinary tall chimney or through the washer, and thence up a dwarf chimney, which in this case was an old boiler flue set on end. The experiments made when we were present were merely to establish in a rough way the features claimed in favor of the apparatus. The stoking of the fires was carried on so as to produce black smoke in the greatest possible quantity, which was caused to issue from the tall chimney to exhibit its quality. It was then sent through the smoke washer, and as it emerged from the short chimney attached thereto the change in its appearance was quite remarkable. It resembled dirty steam more than anything we can think of, and became quite invisible at the distance of a few yards from the chimney top. The cause of the condition in which it appeared gave rise to much speculation, and to show that it was not due to soot, as ordinarily understood, a wet white handkerchief was held for ten minutes in the issuing smoke, and after this exposure it could scarcely be said to be soiled in the least degree, whereas a wetted handkerchief held in the flue at the foot of the tall chimney, and in smoke that had not been washed, was blackened considerably with a much less exposure.

To illustrate the efficiency of the apparatus as an absorber of poisonous acid gases, we cannot do better than cite a few of the results of an exhaustive series of experiments carried out with it by Mr. C. Estcourt, the city analyst of Manchester, assisted by Mr. F. F. Goodfellow, and we regret that our space will not allow us to record their conclusions with greater detail. Tests were made under various conditions of liquid contained in the tank. When it was water only, from 75 to 80 per cent. of the sulphurous gases were withdrawn from the smoke; when the water was mixed with soda ash, or with milk of lime, and always kept alkaline, they were totally absorbed. For practical purposes lime is recommended, and for efficient working it is only necessary to add at intervals a sufficient quantity to keep the liquor alkaline. The lime neutralized by the acid vapors falls as sediment to the bottom of the tank, and is occasionally raked out as mud, which, after drying on the top of the machine, has a composition that indicates its suitability as a disinfecting powder, as may be seen from the subjoined analyses:

Sediment from Tank.	Condition of the Contents of the Tank during Experiments.	In 100 parts. Calculated as Sulphur. From Calcium Sulphate.	From Calcium Sulphite.	Quantities found. Calcium Hydrated Sulphate.	Calcium Sulphite.	Calcium Carbonate mixed with a little Hydrate.	Blacks or Insoluble Carbonaceous matter.
Dried upon the top of apparatus	Alkaline	8·38	5·48	45·02	20·56	29·72	3·5
Do. do. but then kept two months exposed to air, and not redried	Alkaline	7·54	4·61	40·57	17·25	28·35	
Dried quickly in laboratory	Acid	14·66	3·48	78·76	13·00	6·00	
Fresh wet sediment containing 62 per cent. water	Alkaline	2·69	4·58	14·51	17·18	4·00	
a A well-known disinfecting powder to compare with sediment from the smoke condensers		4·59	5·30	23·60	17·18	51·35	

The sample of disinfecting powder marked *a*, the real value of which is known to depend upon the sulphite of lime it contains, contains a small percentage of carbolic acid, and sells at £12 per ton. As will be seen, it does not contain more of the active element, sulphurous acid, than the dried sediment from the smoke-washing machine.

The only water lost in the apparatus is by evaporation, and to keep it at the proper level in the tank a common ball tap is provided. The quantity of lime required depends upon the quality of coal and the amount consumed, but may be said to be about one ton of lime for every fifty tons of coal consumed—that is, when the latter contains about two per cent. of sulphur.

In conclusion, we consider we only do our duty in asking the attention of our readers to this method of obviating the smoke nuisance. When manufacturers are summoned it is not uncommon for them to plead that they spend hundreds of pounds in trying to abate this nuisance. It is certainly now in their power to attain this object, and with no great expense, for the resulting compounds may be reasonably expected not only to reduce the cost to a minimum, but may possibly be actually turned to profit where the amount of sulphurous acid, which at present escapes, exists in very large quantities.—*Textile Manufacturer.*

DEPREZ'S MAGNETO-ELECTRIC MACHINE.

DEPREZ uses a horse-shoe magnet, placing between the two branches a Siemens coil, which is revolved around an axis parallel to the branches of the magnet and provided with proper commutators. The length of the helix is nearly equal to that of the rectilinear branches of the magnet, so as to use nearly all the inductive power of the branches.* With a battery of five Bunsen elements and a magnet weighing 1·7 kilogrammes (4·54 pounds), he obtained as satisfactory results a with a Gramme machine, which had a permanent magnet weighing at least 20 kilogrammes (80·4 pounds).—*Bull. de la Soc. Franc. de Phys.*

ON THE ROLE OF THE EARTH IN ELECTRICAL TRANSMISSIONS.†

THE part taken by the earth in the transmission of electricity has been, and still is, so often imperfectly understood that it has appeared to us that it would be of interest to our readers to have some light shed on this subject.

Does the terrestrial globe behave in its whole mass like an ordinary conductor, and which makes up for its tolerable conductivity by the size of its section? Or, indeed, is it a conductor only through the intermedium of the numerous water-courses which run over it in all directions? Or, again, does it play the part only of a simple absorbent of the electric fluid? These are the questions that we have to deal with. But provided we analyze them with scrupulous care, we will discover that they may be easily reconciled, and that the misunderstanding which has prevailed has arisen more especially from the wrong interpretation that has been put upon the word *conductivity*. In fact, MM. Kirschoff and Smaasen, as a sequence of important labors and numerous experiments in unlimited media, have been enabled to show that in conductors as vast as the terrestrial globe, the electric flux *does not spread between two buried plates in a single direction, but indeed by radiating in all directions at once.* So that these plates are like centers of electrical dispersion, which, at first sight, might cause us to have faith in a sort of absorption by the earth around the electrodes. But it is easy to see by the currents which may be collected by derivation in the space near the plates, and which are in different directions according as they are taken between the plates or back of them, that the *whole mass of the earth takes part in conduction;* and, by applying to this case of transmission the formulas of Ohm on the diffusion of electricity, MM. Kirschoff and Smaasen have discovered that in the *conditions* of an unlimited medium cut by a plane—and these conditions are those of the terrestrial globe—the resistance offered to the transmission of a current from one buried plate to another *is independent of the distance which separates these plates, and varies only with the extent of their surface and the mean conductivity of the neighboring medium.*

The positive formula which represents in effect this resistance is expressed, according to MM. Kirschoff and Smaasen, by $\frac{1}{K\pi\pi\theta}$ where K represents the coefficient of conductivity, and θ the radius of the electrode, supposed to be spherical for ease of calculation. Now, it is easy to derive from this formula the preceding deduction, since the distance between the electrodes is eliminated therefrom, and the quantity θ, which figures in the denominator, shows that this resistance is in inverse ratio to the radius of the electrode, or, what amounts to the same thing, *in a ratio inverse to the square root of the surface of this electrode.* From this way of putting the matter, it results that the *direct conductivity* of the medium interposed between two electrodes is of little importance in the phenomenon of electric diffusion in the case under consideration, and hence that transmission through the medium is effected as if the two electrodes were in connection with two absorbents of electricity. However, the formulas from which the principles just stated have been deduced are wholly derived from the laws of conductivity. The different interpretations that have been given the phenomenon of transmission by the soil are then, in fact, perfectly true; only, if we liken this phenomenon to an action of conductivity, we cannot admit that the soil behaves between the two plates like a more or less resistant simple conductor in which the current has a determinate direction. It is in the interpretation of this rôle of the earth that lies the whole difference between the two opinions, and it must not be thought that this interpretation has not its *raison d'être* and its importance; for, outside of the sequences which result therefrom for the laws of electric transmission between two buried plates, experience shows that often it is not a matter of indifference whether the connection of the two extremities of a circuit be effected by a metallic wire or by the earth, and that very different results may ensue from it in the very mode of the transmission of electricity through the circuit. When the connection is metallic the negative current and the positive current are diffused simultaneously in each half of the wire till they meet; so that the action of the current makes itself felt first at the poles in communication with the wire, and is revealed in the middle of the circuit only at last. When the connection is formed by the earth, the action of the current makes itself first felt at the pole in communication with the wire, and reveals it at the end of the circuit in connection with the earth only at last. By reason, however, of the feeble resistance of the earth, this extremity is separated from the second pole by an interval only that might be considered as *nil.* Under these circumstances we might have faith in an absorption of the two fluids by the soil rather than in the conductivity of the latter; but we must consider that in this case the two poles of the pile are not placed under the same conditions. One of these poles, in fact, communicating with a mass of infinitely great size, can charge it only to a potential not exceeding zero, and consequently only the pole which is in connection with the linear conductor can cause the movement of the electricity in the circuit, and which is effected under the influence alone of the electric tension which is developed at this pole of the pile. This is the reason why the movement of the electricity takes place successively from the pile to the extremity of the wire. As to the opinion which attributes the conductive property of the earth to the water-courses which groove it in all directions, it is confounded with those that we have just studied; for we shall see that beyond two or three meters the conductivity of these courses becomes confused with that of the terrestrial mass.

There do exist, however, in the earth's rôle as a conductor, conditions which vary according to the tension of the source of electricity. If this tension is considerable a simple contact with the earth suffices to dissipate a charge; and every one knows how easily a machine loses its electricity. If the tension is feeble the contact with the soil must be better assured, and the intervention of connecting plates is indispensable. Finally, if the electric charge is the result of voltaic action, the wires must be in connection with the soil at the two extremities of the circuit; for in this kind of electrical manifestation the two electric fluxes are mutually dependent on each other in their movements, and a wire can only be charged if the contrary charge can be dissipated, in the same proportion, or another conductor of the same length or of an infinitely great mass, as in the earth.

The conductive power of the earth, and the possibility given by it of furnishing by derivation small currents which result from the diffusion of electricity through the whole mass, has put the idea into the minds of several savants of substituting it for the conducting wires themselves, and of thus obtaining telegraphic transmissions without the aid of the latter. From the time of the erection of the first telegraph lines in England and America experiments have been made to this end, and results were even obtained which were at first astonishing, but which were promptly explained. In the work of Mr. Vail on the American electro-magnetic telegraph, published in 1847, may be seen the experiments which were undertaken in America in 1842 and 1844 by Messrs. Morse, Gale, Vail, and Rogers, and I myself have, in the different editions of my "Exposé of the Applications of Electricity," published in 1853-6 and 1871, noticed those which were made in England and Germany by MM. Van Riess, Gintl, and Lindsay. Again, three years ago the American journals with a great flourish of trumpets reported experiments of the same kind, which they asserted to be a new and marvelous discovery, but which had been undertaken during the siege of Paris by M. Bourbouze, formerly of the Sorbonne. It is true that M. Bouchotte believed it to be his duty to claim piority on this subject, pretending that he had made experiments of the same nature in 1858. The fact is there was nothing new in this idea, and all those who have studied electrical diffusion in liquid masses must have infallibly arrived at the conclusions that have called forth these experiments. In 1857 M. Menant had even published in *Science* an interesting article on this subject, wherein he showed the direction of the currents thus derived from the liquid mass, according as the derivation was taken between the electrodes or behind them.

The experiments in regard to transmission without conducting wires have generally been made with the aid of metallic plates sunk or buried at the two stations which were to enter into correspondence. These plates, two in number for each station, should be separated from each other slightly in a lateral direction at each of these stations, and, according to the experiments of Messrs. Morse, Gale,

* See *Journal of the Franklin Institute*, August, 1879.

† Translated from *La Lumière Electrique.*

Vail, and Rogers, if the intervening medium is a river the maximum of electrical effect transmitted from one bank to the other should be obtained when this lateral distance of the plates sunk in each bank is triple the width of the river itself. This deduction, however, does not appear to me susceptible of realization, but it has been proved as a result of these experiments that the intensity of a current thus transmitted increases with the size of the plates. As to the arrangement for the experiment itself, it was generally very simple: The galvanometer of the telegraph was put in direct communication with the two plates at the receiving station, and the two other plates were connected at the transmitting station on one side with the pile, and on the other with the manipulator, which itself was connected on another hand with the pile. It was thus possible to exchange telegraphic communications in 1844 across the Susquehanna River, at Havre de Grace, near Baltimore, and which at this point is about a mile wide; and in 1855, between Gosport and Portsmouth, across an arm of the sea about one and a half miles wide. M. Bourbouze's experiments in 1871 were made along the Seine, between the Napoleon and Austerlitz bridges, a distance of about a mile and a half. To obtain a deflection of 25° to 30° in a sensitive galvanometer he had to employ a pile of 600 elements. It is true that the arrangement for these experiments was a little different from the preceding, in that the plates, instead of all being submerged in the Seine, were plunged both in the water and in the earth at each station, thus exciting locally the formation of a telluric current which had to be annulled by a counter current, and the latter was furnished by a small auxiliary pile, the intensity of which was graduated by means of a rheostat.

If the arrangement of these different experiments be studied, we may easily ascertain what the electrical effects are that are produced under these circumstances, for from what has been previously seen, and from the researches of MM. Kirschoff and Smaasen, we can readily understand that whatever be the position of the plates connected with the receiver, there always exists a part current which must pass from one to the other, and which is consequently derived more or less easily through the galvanometer of this receiver. It may be conceived that this part current can be only very small as compared with that which passes through the wires of the generator, and it is the much more so in proportion as the distance is less which separates the plates from each other at each station, and as the stations themselves are more widely distant from each other. The formulas of Kirschoff, however, permit us to determine it, and if the calculation be made it will be very quickly seen that beyond a certain distance, and which is not very great, it is entirely impossible for the apparatus to work.

With a liquid intermedium between the two stations, the effects are quite simple when the metallic plates have equal surfaces and are very homogeneous; but if the earth be taken as an intermedium they are much more complex, because a host of accidental currents tend to arise between the plates buried at each station, and put them in electrical states which are different enough to prevent the effects just analyzed from taking place. From this it may be understood that, in this case, it is essential that these currents should be neutralized before the exchange of correspondence, and it is for this reason that M. Bourbouze had to employ compensation currents; but the latter are not useful when an intermedium which is entirely liquid and very homogeneous is the kind employed. If M. Bourbouze did not obtain good results in employing this means, and if he obtained better ones by plunging one of his plates in water and burying the other in the vicinity at each station, it was because he had not in the first case separated his plates enough from each other, and because with the arrangement that he adopted he established, without suspecting it, a resistance of at least 2½ to 3 miles of telegraph wire between the two plates at each station. He would have needed an equivalent resistance of a liquid between these same plates in order to obtain the same effect in using the Seine as an intermediate conductor.

The experiments made by M. Van Rees at Portsmouth, in 1855, caused a certain furor at the time, and several scientists began, dating from that period, to devote their attention to them. Thus it was that M Gintl made known, towards the year 1858, the results of the experiments that he had undertaken in using the earth itself as a conductive medium, and in England certain minds were in such a state of enthusiasm that Mr. Lindsay, about 1860, declared that this system would resolve the problem of a telegraphic connection between Europe and America. This opinion was based on the fact that, according to his experiments, electrical transmissions of the kind just considered depend on three elements, which it is always easy to make vary: (1), on the strength of the battery employed; (2), on the extent of surface of the metallic plates establishing the communication of the apparatus with the liquid at the two stations; (3), on the lateral distance of these plates at each station. "Whence it results," said he, "that with two properly chosen stations, one at the south of England, and the other in Scotland, and two other corresponding stations equally well selected in America, it would be possible to transmit telegrams directly across the Atlantic ocean." It may be well understood that these five hopes had to be abandoned after a serious examination of the question. It is generally admitted that the resistance of the earth in telegraphic circuits must be considered as *almost null*, at least if we have what is called *good earth*.

What should be understood by these terms, "resistance almost null" and "good earth?" This I will endeavor to make clear.

Although the terrestrial globe, by reason of its immense section and the diffusion of electricity throughout its whole mass, behaves like a conductor without resistance, or like an absorbent of the electric charges which may be transmitted to it, it constitutes a more or less humid medium, which, being put in contact with the terminal plates of a circuit traversed by a current forms a true electrolyte whose plates are the electrodes. Consequently, the effects distinctive of electrical transmissions through an electrolyte must be met with, more or less characterized, on telegraphic circuits, and we shall see from the experiments of which I am about to speak that these effects are sufficient to form a sensible resistance. On another hand, if in consequence of the mode of electrical diffusion, which is effected then as in an unlimited medium, the resistance of the earth is independent of the respective distances of the plates (as have demonstrated it MM. Kirschoff and Smaasen), it varies with the size of these plates and depends on the conductivity of the ground around them. We cannot say then that the resistance of the earth is null, and a *good earth* will be that which is put in connection with the line wire by electrodes which have as large a surface as possible and plunging into soil which is as moist as possible. We shall see in a moment what values may be ascribed to this resistance, according to the different ways in which communication is established with the earth; but we may already draw the conclusion from what precedes, that if the intervention of the ground in a circuit presents some advantages over long lines it yet presents all the inconveniences which are inherent to circuits completed by an electrolyte, and may even, on very short circuits, constitute an increase of resistance which may be obviated by using a return wire. It is this intervention of the earth in telegraphic circuits, joined with the derivations of the current all along the lines, that allows certain experiments to succeed admirably when made in a laboratory with gauged resistances, although they fail completely when repeated on the lines.

The terrestrial globe not being an electrolyte of uniform conductivity—some parts being mineral or liquid and good conductors, and other parts being very bad conductors—there is still room to consider the manner in which conduction behaves according to the reciprocal arrangement of these parts. It is readily understood that a good conductor being superposed on a bad one the electrical current will by preference follow the good one, and so long as this good conductor, limited in its mass, preserves a superior conductivity over the bad, which has an indefinite mass, the electrical intensity will be able, independently of polarization and other effects, to vary with the distance of the plates; but there will come a time when this better conductivity will become confused with that of the bad conductive mass and will no longer exercise any influence. Hence the resistance of the entire conductivity will become independent of the distance of the plates, and the intervention of the better conductor will only have the effect of raising the value of coefficient of the mean conductivity of the whole. It is understood from this reasoning that the watercourses which flow over the earth in all directions as well as the metalliferous or carboniferous veins which traverse its crust can react on electrical transmissions in the direction of which we have just spoken, and it became a question to determine to what distance between the electrodes this influence of direct conductivity could manifest itself. From certain experiments which I have undertaken at different epochs this distance was found to vary according to the surface of the electrodes and the nature of the conductor; but for watercourses it is very limited, and beyond 650 to 975 feet it becomes nearly insignificant, at least if the electrodes are in contact with the liquid mass, if the ground forming the bottom of the stream is permeable, and if the width of the latter is great enough. Under these conditions the resistance offered to the current varies from 2½ to 3 miles with electrodes of 20 inches square surface, and the resistance of the ground itself, without the intervention of the watercourse, is comprised within the same limits when the electrodes are plunged at the two ends of the circuit into two wells. When the bottom of the watercourse is composed of a clayey soil the characteristic conductivity of the liquid becomes much less easily confused with the general conductivity of the ground, and it may happen that, in a very slight separation of the electrodes, the resistance of the liquid will be much greater than that of the earth, even supposing for the latter a much farther separation of the electrodes. Thus, with electrodes 150 feet distant from each other in a pond with a clay bottom, there has been obtained a ground resistance represented by 26,700 feet, although with the same electrodes plunged into two very deep wells 525 feet from each other, this resistance was only 14,500 feet. That is owing to the fact that the clayey soil forms then between the sheet of liquid and the permeable parts of the ground a sort of diaphragm which is relatively insulating. When the communications of a telegraph line with the soil are made without precaution the resistance of the latter varies in enormous proportions, which are independent of the distance apart of the electrodes and which it would be often difficult to foresee at first. Thus, although with two plates buried at a distance of 2,700 feet from each other the resistance of the soil reached 81,300 feet, these same two plates buried at a distance apart of 1,900 feet have furnished a ground resistance between them of 286,440 feet; and this was due to the fact that in the latter case the ground in the vicinity of one of the plates was composed of very dry sand, while in the other case the soil was damper. Outside, however, of these different conditions of conductivity of the diverse parts of the soil there are physical reactions due to the very action of the soil on the electrodes, and which, judging by the effects that they produce, would seem to impute to the earth a very variable resistance, and are often out of proportion to its conductive state. These reactions are, as we have said in the beginning, the consequence of the mode of conductivity presented by the soil, and which is wholly electrolytic. They depend on many circumstances: on the relative humidity of the soil around the plates, on the relative dimensions of the latter, on their reciprocal temperature, on the more or less homogeneous metallic nature of the electrodes, and on their greater or less oxidation, on the chemical composition of the waters which moisten the ground in contact with the electrodes, and on the effects of polarization which are caused by the passage of the current. All these causes have for a result the creation of what are called *telluric* currents, which, according to the way in which they are directed with respect to the transmitted voltaic currents, affect the latter more or less and allot a greater or less resistance to the soil, and a resistance which is not at all its real one. Thus, for example, by taking the water mains of the Quartier de Grenelle, at Paris, and a plate of iron 20 feet square buried at a depth of 3¼ feet and 5,600 feet from the point where I had taken my communication with the mains, I have found that the mean ground resistance might be represented by 8,800 feet of telegraph wire when this plate was positive, and by 11,920 feet when it was negative. It is true that a telluric current was then produced and was directed externally from the water main to the plate. With the two 20-inch zinc plates immersed in the two wells, of which I have previously spoken, I obtained, for one direction of the current, a ground resistance of 10,180 feet, and for the other direction 22,460 feet, and I had a telluric current which caused a deflection of 90° 30′ of the needle. Naturally the resistance of the soil was the least when the current proceeded in the same direction as the telluric current. On another hand, the resistances thus determined varied themselves with the time of the closing of the circuit in consequence of polarization, and that too quite largely.—*Th. du Moncel.*

ZINC AS BOILER PROTECTOR.—Zinc introduced into steam boilers to prevent incrustation proves very useful in case of selenitic waters, but as against the carbonates of lime, magnesia, and iron it is of little value. The zinc is soon rendered brittle and porous, and is in course of time reduced to a powder.—*Dr. Kosmann.*

THE MOON NOT A DEAD STAR.*

By Dr. HERMANN J. KLEIN.

THE assertion that there are changes now taking place on the moon's surface, and which are half physical, half meteorological in character, differs so greatly from the opinion generally prevalent, that we ought not to be surprised if it is received with some reserve, or even met by flat denials. When in the month of March, 1878, I announced that there had formed to the east of the crater Hyginus a great depression which also was crater-shaped, and that the mountain called by Mädler the *Snail* had had a large valley annexed to it toward the south, I naturally waited to hear the usual denials of the new formation to which I had called attention. Although I took the precaution to declare that the environs of Hyginus had been known to me for twelve years through numerous observations, there were, nevertheless, several observers that had only occasionally examined this lunar region, who seemed to feel that they were obliged to cast a doubt on this new formation. The most singular confusion arose: some looked for the pretended change in Hyginus itself; others, in the neighboring hills; one said that he had seen a definite shadow; and another believed that he could distinguish a clearer point; while many saw absolutely nothing. This furnishes a striking proof of what had already been advanced, first by Mädler, and then by Jules Schmidt, that no one should permit himself to have any opinion about the moon's surface but he who has been acquainted with it for a long time through his own observations. This being the case, the observer will not refuse to consider as new an object which shows itself in so evident a manner as the little crater near Hyginus, at the moment when the limit of light is in its meridian, that is to say, in that phase under which we prefer to observe that region. It is absolutely impossible that Lohrmann, Schmidt, and Neison could have neglected such an object while they registered on their maps details which were much less important. As to the great part of the open valley to the south of the Snail mountain, it seems to me that we have sufficient positive proof to assert its very recent formation. I have been able to have at my disposal the original journals of the able observer, Gruithuisen, and which have not up to the present time been published. With these journals there are numerous original drawings, so finely and accurately executed as to astonish those who are acquainted with the moon. Among these I found one which bore this title, "End of my river bed; night of 28th November, 1824, half past 5 o'clock." The river bed is nothing but the system of furrows which surrounds the Triesnecker mountain. This drawing exhibits the minutest details, but the great deep valley near Hyginus which must at that moment have been filled with a dark shadow is entirely wanting. Yet Gruithuisen made a special study of the Snail mountain;" he speaks of it, and he sketches a very small furrow which extends from the inner crater toward the southwest. Were it still possible to doubt the recent formation of the valley, the doubt would be dispelled by Gruithuisen's drawing. But now we have a further confirmation on the highest degree of evidence that this kind of human observation can receive. Messrs. Neison and Green, on the 29th of March, made drawings of the crater N. and its surroundings, which are very characteristic and completely in accordance with my own. The *Selenographical Journal* (No. 16) says that, from the measurements of M. Neison, the location of the crater is in +6·47° of Selenographic longitude, and +90·5° latitude. M. Neison remarks that "in every respect, except that of the presence of this black spot, the aspect of this region is exactly the same as I observed it from 1874 to 1875, when I was making my map." I announced the object as a crater, from analogy. It is a crater funnel, and even one of the largest. Toward the south there is a shallow spoon-shaped hollow, which terminates in a second small crater. In full sunlight, when the interior of the large hollow of the crater is no longer in shadow, the spoon-shaped hollow may still be seen as a gray spot. By the use of high powers it is remarked that the environs of the new crater appear to be fissured in a bewildering manner. Two fine furrows, like clefts in the soil, which extend from N. toward the Snail mountain, are the finest objects on the moon. We are unable as yet to decide whether this formation is really volcanic. There is one quite curious fact, however, which would seem to indicate that a mountain of smoke has at one time been seen on the moon. On the 2d of July, 1797, Schröter and Olbers examined a mountain situated in the Sea of Vapors. This mountain, which was ascertained to be 3,450 feet in height, has been seen neither before nor since, and was probably merely a mass of vapor. In the text of Schmidt's lunar map the observation is made that this mountain might possibly be "Silberschlag B.;" but the selenographic element is here in error. It cannot be doubted a single instant, if Schröter's drawing be compared with those of Lohrmann, Mädler, and Neison, and even with lunar maps. The formation measured by Schröter has disappeared from the moon; and, nearly in the same spot, there is now a crater. This is not the place to prove that there sometimes occur on the surface of the moon nebulous strata of very long duration; but it may be stated, however, that these productions have no analogues on the earth. He who examines carefully the materials furnished by the numerous observations made on lunar formations from the time of Gruithuisen up to our own day, will arrive at the conclusion that things are going on upon the surface of this neighboring world which we as yet can know nothing about.

* From *La Nature*.

ON CERTAIN PERIODICAL SPOTS UPON JUPITER.

IN a study published by me some time ago in *La Nature*, on the physical structure of the planet Jupiter, I mentioned among other historical details, the observations made two centuries ago by Dominique Cassini; and, among these observations, those of a spot which seemed at that epoch to present a remarkable character of permanency. This spot, in fact, was observed during six months in 1665, during the six months following of 1666, and the first appearance lasted about two years. The spot afterward disappeared for five years until the beginning of 1672; and then it remained permanently in sight, to become again invisible in 1675 and 1676. It showed itself anew in July, 1677, then became invisible until March, 1685; then lasted again for two years; and, finally, after a disappearance until to the end of November, 1690, this singular spot again exhibited itself with many others, but always exactly identical as regards its position on the surface of Jupiter's disk.

These old observations, it appears to me, assume to-day a new interest. In fact, I had occasion a few weeks ago to admire a splendid series of astronomical drawings, and among them an entire suite of views of Jupiter, and in

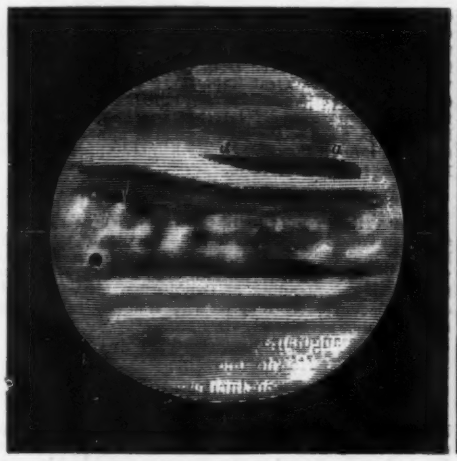
which all the physical peculiarities of her disk as seen day after day are admirably reproduced. These drawings are the work of a well known astronomer—I was about to say of an American astronomer; but, no, he is one of our com patriots, Mr. L. Trouvelot, whom the political events of December, 1851, forced to leave France. This gentleman has employed the leisure moments of his exile in a profound study of astronomy, and is one of the scientists who have contributed to render the observatory of Harvard University celebrated. I was already acquainted with the splendid researches published by him in the *Annals* of the observatory, and in the last edition of my work on "The Heavens," I reproduced his drawings of the protuberances, as well as one of Saturn. Mr. Trouvelot came over last autumn to visit France, and had the happy idea to bring along with him his collection of observations, designing, it must be said, to have the satisfaction of publishing them in his native country. It is to be desired that this hope will be realized; and I express still another wish, and that is to see so experienced a savant return to us. We are sending our astronomers to foreign countries (M. Liais as another instance) as if our observatories were glutted.

But to return to Jupiter and his spots: I have remarked among the beautiful drawings, in which Mr. Trouvelot has traced with minute fidelity all the accidents of surface of this planet, certain ones in which a singular spot is seen, and which is interesting not only because of its form and color, but also because of its permanence and periodicity. The latter characters have reminded me of the spot seen and described by Cassini, and it has seemed to me that it would prove interesting to compare these observations, which, at two centuries apart, present an analogy that must be instructive.

Mr. Trouvelot has had the goodness to intrust me with two of these views of Jupiter, in which this spot is represented, and which are reproduced herewith. But it is necessary to join to these the detailed description which the observer has given in *The Observatory*, and which is as follows: "Prof. C. W. Pritchett having lately published in *The Observatory* an account of a remarkable red spot on Jupiter seen by him on the night of July 9, 1878, it may be of some interest to recall the observations of a similar phenomenon seen recently at Cambridge, especially since the two phenomena seem to be closely connected. On making an observation of Jupiter, September 25, 1878, at half past six o'clock, a remarkable similar object had been seen two months before. The return of certain spots on Jupiter at the same place where like forms had been already observed before, although a very rare phenomenon, is not, however, without precedent, if I may judge of it by my observations of this planet. For example, the angular appearance of the southern edge of the equatorial belt, described above, and in the vicinity of which the red spot made its appearance, very strikingly demonstrates the phenomenon of return; since this spot, which is so familiar to me, has disappeared and reappeared three times during a period of observations extending a little over a year.

Perhaps it is important to remark that the two spots whose appearance I have observed are situated very near each other. The angular spot of the southern edge of the equatorial belt was not once seen in 1876, during the 130 nights on which Jupiter was observed; but it was seen for the first time on the 14th of April, 1877, on the second day of my observations of this planet that year. It continued to be visible for six months, up to the 14th of September; after that date the spots of this region of Jupiter changed and became entirely different. On the 16th, 18th, and 22d of September, the planet was showing the same face to the earth; the definition during these nights was good and the atmosphere was clear, but the characteristic spot was not perceived. However, on the 26th of September (twelve days afterward) the same remarkable form was again seen at the same place, and continued to be visible for 41 consecutive days up to the 6th of November. The same region of the planet was observed on the 13th, 15th, and 17th of November; the angular spot was not there, but, in its place, there was seen a uniform rectilinear border. Twelve days after, on the 19th of November, a similar form reappeared in its place, with its characteristic projecting point. The observations of Jupiter were discontinued on the 10th of December, the planet then being too near the sun, and they were not systematically resumed again till September 6, 1878. On the 8th of the month, an angular spot, exactly resembling the one observed during the years preceding, was seen at the same part of the southern border of the equatorial belt. On the 10th and 15th of September, it ought to have been seen, since the planet was presenting the same hemisphere to the observer; but, in its stead, the edge of the belt was uniformly rectilinear. About twelve days after, on the 20th of September, to my surprise, a similar form reappeared at the same place, arranged as before, and remained visible from that date, without any change, up to the end of my observations on the 12th of January, 1879, when Jupiter was too near the sun to be observed. The return of the angular spot was observed and drawn 62 times during the twelve months on which observations were made of Jupiter on clear nights.

This singular recurring phenomenon seems to indicate that local causes participate in a certain measure in the production of these Jovian spots, and the return of the same appearance on three different occasions, just twelve days after its disappearance, appears to indicate that there is a periodicity in the mode of action of these causes. Were it proved that local causes sometimes produce spots on Jupiter, such spots would be the best objects to take in order to calculate the period of the planet's revolution, since they would be less subject to possess a motion of their own."—*Amédée Guillemin.*



SPOTS ON JUPITER OBSERVED AND DRAWN BY M. TROUVELOT.

FIG. 1.—Observation made September 25, 1878, at 6 h. 30 m.

FIG. 2.—Observation made December 23, 1878, at 5 h. 22 m.

red spot was seen just above the southern border of the equatorial belt, its center being then situated a little to the east of the central meridian. This curious object, which apparently occupied a fifth of the diameter of the planet, was very clearly defined; and its color, which was of an intense rose, formed a striking contrast with the luminous white ground on which it was projected. It was of the same uniform shade from one end to the other, without any dark border, and its rose color forming the entire spot. It appeared isolated and entirely independent of the equatorial belt, from which it was separated by a brilliant white band. As to shade, the color of the spot differed totally from the pale rosy tint of the equatorial belt, or from any other object that I have ever seen on Jupiter. A mixture of vermilion and blue would almost give the tint of the spot. Fig. 1 is a copy of the original drawing which was made immediately after the observation, *a a*, being the red spot. Since this observation was made, the return of the spot has been observed and drawn fifteen times, and the last time it was seen was on December 30. After this period it became impossible to follow it longer, owing to the proximity of the planet to the sun. The form of the spot changed somewhat during this period; for when first observed it was narrow and elongated (Fig. 1, *a a*), but finally it became shorter and much broader, and extended farther toward the south.

It is, perhaps, a very curious fact that this object should have corresponded very nearly in position with the elliptical rosy cloud observed by Prof. Pritchett on the 9th of July, or 77 days before I saw it for the first time—the planet having in the interval made nearly 188 revolutions. However, it was certainly not identically the same spot as the one seen by Pritchett, since he was unable to see it on the 11th and 15th of July, when it should have been visible had it remained stationary, and since I was not able to see it either on the 6th, 10th, 15th, 20th, and 22d of September, when Jupiter presented the same region to the observer. Between the 19th and 20th of September, considerable changes took place in the planet's spots, the southern edge of the equatorial belt exhibiting at one point a very characteristic angular form, which, on the 25th, was seen to the west of the red spot and all to one side. Had the red spot existed on the 20th of September, it would have been impossible not to remark it, as the definition was very clear that night, and I had obtained a good drawing of Jupiter. Consequently it seems certain that the spot was formed between the 22d and 25th of September, for it was not seen at 7 o'clock on the 22d.

It is very remarkable that this spot should have appeared precisely, or at least nearly so, at the same place where a

THE MICROSCOPE AS A MEANS OF INVESTIGATION.

AT a meeting of the Biological and Microscopical Section of the Academy of Natural Sciences, Phila., Jan. 18th, 1880, Director, Dr. Carl Seiler, in the chair, the regular business of the Section was deferred until after verbal communications.

DR. SEILER then introduced the subject for the evening.

THE MICROSCOPE AS A MEANS OF INVESTIGATION.

The various parts of a working microscope were carefully described. The use of a sub-stage condenser and proper illumination were especially dwelt upon, and a definition of proper illumination was given.

To constitute a good microscope, the lecturer said, the various parts must work well together. He went on to say that it is necessary for the sub-stage condenser to have a good centering arrangement, and that a condenser not properly centered is worse than none at all. In order to center this apparatus, a low power, viz., an inch or $\frac{1}{10}$ objective is placed on the tube, and a cap with a small hole is fitted over the front combination of the condenser; the latter is then moved upwards until the image of the hole in the cap is in focus, when it will readily be perceived whether it is central to the axis of the microscope, and if not, can easily be made so.

The mirror also must be absolutely centered to get the best illumination. It is further important to use the cap to regulate the amount of light.

The best test for correct illumination is the examination of a thin layer of blood upon a slide. To prepare this, a drop of blood is placed upon a slide and the edge of another slide is placed on it so that the blood spreads in a thin line over the whole width of the first slide by capillary attraction. The second slide is then rapidly moved over the first one, keeping the edge in close contact with the surface, and thus the blood is spread out in an even layer.

Attention to the kind of light is all important. A light agreeable to the eye must be steady. It must be white and concentrated by means of a bull's-eye condenser. The disk also must exactly cover the mirror, or must, at least, be in the center. This can be done by placing a white handkerchief over the mirror and drawing it tight so that the outline of the mirror frame shows itself. The disk of light can then be adjusted so as to fall in the center of the mirror. A blue tinted glass should be inserted at the bottom of the well which holds the sub-stage condenser in order to neutralize the yellow rays emanating from most sources of artificial light in use for illuminating the microscope. The important part which illumination plays in the measurement of objects was shown by the effect of proper and improper illumination upon blood corpuscles.

Improperly illuminated, the disks, even with the best known objectives, show concentric rings on their surface, and their outline appears to be lost in a mist or, shadow, making it is impossible to tell where the corpuscle ends. On the other hand, when the light is properly managed, these corpuscles show a well defined, sharp outline, and their surface appears evenly tinted.

Improperly illuminated white blood corpuscles, the granules, as well as the Brownian movement, can be perfectly seen.

In order to do this satisfactorily, however, the white blood corpuscles must be isolated, which can be done by allowing a drop of water to run under the cover glass which has been placed upon a drop of blood. The red globules are thereby washed away, because they are smaller than the white ones, which are left behind as the sole supporters of the cover glass.

Illumination of opaque objects may be accomplished by placing the light before the stage and allowing the direct rays to fall upon the object, by interposing the bulls-eye condenser, by means of the Lieberkühn, or more simply still by throwing the mirror around and above the stage so as to concentrate the reflected rays upon the object. This latter method is applicable only to those instruments whose sub-stage and mirror bar swing in the plane of the object and the stage.

The doctor, in conclusion, called attention to a specimen prepared with Canada balsam which he exhibited in which were numerous fat crystals in the fat cells.

Some of the members had previously doubted the possibility of showing these crystals in a balsam preparation.

The Hitchcock lamp was then exhibited to the section.

An artificial draught is produced by means of a fan concealed in the body of the lamp which is worked by machinery.

This arrangement renders the use of a chimney unnecessary, and the draught is so arranged as to consume all the carbon.

INFLUENCE OF SHAPE UPON ATTRACTION.

C. LAGRANGE refers to the following proposition, which he demonstrated two years ago: "When attraction varies inversely as the squares of the distance, if the distance is considerable, any mass acts with maximum, mean, and minimum energies, in three rectangular directions which are respectively the axes of minimum, mean, and maximum inertia." From this proposition he deduces the following results: "1. A mass of any form, at a certain definite distance from its center of inertia, acts with maximum, mean, and minimum energies, in three rectangular directions, which coincide respectively with the three axes of minimum, mean, and maximum inertia. 2. The relative positions of a point and of a material system, submitted to their mutual attraction, are determined by the stable axes of equilibrium in the system; the axes of minimum, mean, and maximum inertia are respectively axes of stable equilibrium, stable in one plane and unstable in a perpendicular plane, or unstable." The first of these deductions he regards as fundamental in the mechanical theory of crystallization. —*Acad. Roy. de Belg.*

A NEW LECTURE EXPERIMENT—THE CUPELLING OF GOLD AND SILVER.

MR. HOLMAN, the actuary of the Institute, has constructed a lantern for the oxyhydrogen light which combines a great many advantageous qualities. It may, at a moment's notice, be changed into a vertical lantern for showing precipitations, the action of a magnet on iron filings, etc., on the screen. It may be converted into a projecting microscope in a twinkling, and with equal facility it becomes a megascope for projecting the image of solid objects. A course of lectures by Mr. A. E. Outerbridge, Jr., of the U. S. Mint, was recently delivered before the members of the Institute on "Coins and Coinage." By the aid of Mr. Holman's apparatus the enlarged images of rare and valuable ancient and modern coins were projected upon the screen with great sharpness and brilliancy, having the luster and effect of relief of the coins themselves, and the lecturer was enabled to show the cupellation of gold and silver, as performed in the assaying of the precious metals at the Mint, in a very beautiful manner to the entire audience, thus opening up a new field of usefulness for the projecting lantern in illustrating lectures on metallurgy.

A little "cupel" or crucible, made of calcined bone ash, was held in the focus of the light from the condensing lenses of the lantern, by means of a ring of thick copper wire. The image of the cupel appeared upon the screen greatly enlarged. The cupel was then heated to a white incandescence by means of an oxyhydrogen blowpipe. A weighed sample of gold alloy containing base metal was inclosed in an envelope of sheet lead pressed into the form of a bullet; this was dropped into the cupel and was immediately melted. As the lead became oxidized it was gradually absorbed in the cupel, forming a dark ring in the bottom. A little sheet of light was noticed moving over the surface of the molten metal as the non-oxidizable precious metal became exposed to view; then, at the moment that the lead became completely absorbed, carrying with it all the base metal originally contained in the alloy, the purified precious metal became visible as a brilliant globule, reflecting the light falling upon its surface like a mirror.—*Jour. Franklin Institute.*

THE ORIGIN AND CLASSIFICATION OF ORE DEPOSITS.*

By J. S. Newberry.

The mineral matters which have proved useful to man form three categories; first, the earthy: as gypsum, clay, marble; second, carbonaceous: as coal, lignite, petroleum; third, metallic: as iron, gold, silver.

The metals occur rarely native, oftener as ores, that is, combined with sulphur, silica, carbonic acid, etc. These form a series of deposits, of which the physical and chemical characters and history differ widely. They may be grouped into three classes, as follows:

1. Superficial deposits.
2. Stratified deposits.
3. Unstratified deposits.

SUPERFICIAL DEPOSITS.

These include the accumulations of gold, stream tin, platinum, gems, etc., which are obtained from the surface material, gravel, sand, and clay, derived from the mechanical decomposition of rock masses through which metals or ores were sparsely distributed. Thus gold usually occurs in small quantity in the quartz veins of metamorphic rocks. By the erosion of these rocks, having been freed from its matrix, and that more or less perfectly removed, this gold is concentrated by a natural washing process similar to that employed by man, but on a grander scale. In the same manner the oxide of tin, which is hard, heavy, and very resistent to chemical agents, is distributed sparsely through granitic rocks, or vein stones; and where these have been eroded the cassiterite remains in the alluvial deposits of streams, where it can be cheaply and easily collected.

Superficial deposits have probably furnished nine-tenths of all the gold that has been obtained by man, the greater part of the tin, all the platinum and its associated metals—iridium, osmium, etc., and all the gems except the emerald, which in South America is obtained by mining. Thus it will be seen that the surface deposits are scarcely less important, economically, than the others. The superficial deposits of gold are for the most part confined to the foothills of mountain ranges, and are the products of the erosion effected by ages of frost, sun, rain, and ice, which are continually wearing down all the more elevated portions of the earth's surface. Shore waves also, in some instances, have worn away the rocks against which they have beaten, and have produced accumulations of *débris* that contain gold, platinum, gems, etc., in sufficient quantity to be economically worked. When a beach deposit of this kind has been raised above the sea level, it sometimes becomes convenient and profitable mining ground. On the coast of Oregon, at and above Port Orford, the beaches now yield gold, iridium, and osmium in sufficient quantity to afford profitable employment to quite a mining population, and in the Black Hills the old Potsdam sandstone beach, formed by the beating of the Silurian sea upon the cliffs of Laurentian and Huronian rocks traversed by auriferous quartz veins, now constitute what are there known as the "cement deposits," from which a considerable portion of the gold of this region is obtained. As has been mentioned, however, the chief supply of gold in all ages has come from the *débris* that has accumulated at the foot of mountain slopes. All mountain *chains* are composed of metamorphic rocks, and nearly all the mountain ranges of the globe are traversed by quartz veins, in which are concentrated much of the gold that was originally finely disseminated through the sedimentary strata—conglomerates, sandstones, shales, etc.—now granites, schists, and slates.

By the lateral pressure that has metamorphosed the sedimentary rocks, and produced the segregation of the quartz veins, great folds and ridges were formed, which, rising high above the general surface, act as condensers of moisture, and receive the most copious precipitation from the clouds. Hence on these mountain sides an enormous system of water power is developed, which is spent in grinding up the rocks and transporting the *débris* to the bottom of the slope. Here it is further washed, sorted, and the gold locally concentrated to form the rich "placer" diggings. As no great skill or expensive mining machinery is required to work the placer deposits, every man with good health, a pick, shovel, pan, and stock of provisions, may go into the business. Gold washing is the simplest, as it was probably the earliest of all mining enterprises, and has at different times employed nearly the entire population of a district or country; it is not surprising, therefore, that it has resulted in the production of an enormous quantity of gold. It is evident, however, that most of the placers of the world have been already exhausted, and while the little known continent of Africa promises to furnish a large amount of the precious metal from its "golden sands," we can hardly expect that the production of California, Australia, and New Zealand will ever be repeated in the world's history.

STRATIFIED DEPOSITS.

These may be subdivided into several groups, such as

1. Ore forming entire strata; *e. g.*, beds of iron ore.

2. Ore disseminated through strata; as copper in the schists of Mansfeldt, and in the sandstones of Lake Superior.

3. Segregated masses in strata; as sheets of copper in the Lake Superior sandstones; balls, kidneys, and sheets of clay ironstone in the shales of the coal measures, etc.

UNSTRATIFIED DEPOSITS.

These have been divided into

1. Eruptive masses.
2. Disseminated through eruptive rocks.
3. Contact deposits.
4. Stockworks.
5. Fahlbands.
6. Impregnations.
7. Chambers.
8. Mineral veins.

Of *eruptive masses* of metalliferous matter I must confess myself incredulous. Examples of these are cited in the crystalline iron ores of the Island of Elba, those of Nijni Tagilsk in Russia, and in Sweden, and even the iron ore beds of Lake Superior and Missouri. As late as 1854 this was the view taken of our crystalline iron ores by Whitney, in his "Metallic Wealth;" but great advances have been since made in our knowledge of these deposits, and it is now generally conceded that all our crystalline iron ores are simply metamorphosed sedimentary beds. The evidence is accumulating that those of the Old World have the same character. Professor Otto Torell, the Director of the Geological Survey of Sweden, recently told me that he had visited all but one of the iron districts of Sweden, had found that in all these the iron ores were metamorphic, and he had no doubt that those yet unexamined were of similar nature. Where metamorphic action has been peculiarly violent, the beds of iron ore have been more or less dismembered, and perhaps in some instances have been actually fused; but that any bed of iron ore is the result of an eruption from the interior of the earth is scarcely to be credited.

The examples of the occurrence of metalliferous matter *disseminated through eruptive rocks* are by no means uncommon, and the amygdaloid traps of Lake Superior, in which the cavities formed by gases have been more or less perfectly filled with copper, suggest themselves at once. Pyrites, magnetic iron, and platinum are found sparsely diffused through trap rocks, and are sometimes concentrated in such a way as to form valuable deposits when the trap decomposes.

Contact deposits are usually understood to be accumulations of metal or ore along the planes of contact between two strata; and the sheets and strings of copper which are concentrated at the junction of the trap and sandstone in some parts of the south shore of Lake Superior, constitute illustrative examples of this class of mineral deposits. There is, however, considerable diversity in character among the deposits grouped under this head, the chief distinction being that in some cases the ore or metal has been segregated from one or the other of the strata at the time of their deposition, and in others it has come from a foreign source, and has been deposited in a more or less continuous sheet in cavities formed between the surfaces of the adjacent rock beds. To the second of these classes would seem to belong the argentiferous ores of Leadville, Colorado. These are deposited along the plane of junction between an underlying limestone and overlying porphyry, and undoubtedly accumulated in vacant spaces formed by the solution of the limestone. These ore bodies have apparently much in common with the pockets and chambers excavated in certain limestone beds, and subsequently filled with ore, to be described further on. The true structure of these Leadville ore bodies can, however, only be accurately learned when they shall be penetrated below the zone of unchanged sulphurets into which they will undoubtedly merge in depth.

The term *Stockwork* is applied in the Old World to a mass of rock or veinstone penetrated in all directions by small intersecting sheets or veins in such a way that the whole mass is mined out. Some examples of this kind of deposit may be found in most of our mining districts, but the most important which have come under my observation are in the Oquirrh Mountains, in Utah, and at Silver Cliff, Colorado. In the first of these localities beds of quartzite, in the second, of porphyry, have been shattered, and the crevices between the fragments have been filled with ore deposited from solution.

The name *Fahlband*, or rotten layer, originated in the silver mines of Kongsberg, in Norway, where there are parallel beds of rock impregnated with the sulphides of iron, copper, zinc, etc., and which, by their decomposition, have rendered these beds so soft as easily to be removed. We occasionally meet with pyritous rock in this country, which decomposes in the same way, but none yet known to me have any considerable importance as metalliferous deposits.

Impregnations may be defined to be saturations of porous rock with a mineral solution or vapor from which ore has been deposited. The cinnabar which is sometimes found impregnating unchanged or metamorphosed sandstone, is generally cited as affording typical examples of impregnations. In such cases, which occur in California and South America, the deposit of ore has been ascribed by some writers to vapors, by others to solution, and it would seem that the latter is the more credible theory, although the vaporization of mercury is easily effected, and, like other metals, it may be transported by steam, as we have proof at the geysers in California. More familiar and satisfactory exhibitions of impregnation are, however, afforded by the copperbearing sandstones of Lake Superior, New Jersey, and New Mexico, and the silverbearing sandstones of Silver Reef, in Southern Utah. In all these cases it is evident that a porous rock was once saturated with a metalliferous solution, from which, in the Lake Superior region, metallic copper was precipitated; in New Jersey and New Mexico, sulphides of copper and iron; at Silver Reef, sulphide of silver. As such repositories of the metals are easily penetrated by surface water and air, we usually find the sulphides decomposed to a considerable depth; the copper ores converted into carbonate and silicate, the sulphide of silver into the chloride.

Chambers or *pockets* in limestone form the receptacles of ore in many countries, but nowhere else are such striking examples of this class of deposit as those found in our western mining districts. From a study of these I have been led to add them to the catalogue of forms of ore deposit as a distinct and important addition to those given by other writers. The distinctive characters of those accumulations of ore in chambers and galleries has not been heretofore generally recognized, and a want of information in regard to their true nature has led to much litigation and heavy losses in mining. The best examples of chamber mines are the Eureka Consolidated, Richmond, etc., of Eureka, Nevada; the Emma, Flagstaff, Kessler, etc., in little Cottonwood district, and the Cave Mine, near Frisco, Utah. All these mines are alike in this, that the ore is found more or less completely filling irregular chambers in limestone. Some of these ore bodies are of great size, and the aggregate product of these chamber mines is so great as to make it necessary to record this as one of the most important forms of metalliferous deposit. From the Potts chamber in the Eureka Consolidated mine, it is said that ore of the value of a million dollars was taken, while a still larger amount was produced from the great chamber of the Emma. The origin of these chamber deposits is, in my judgment, simply this: A stratum of limestone, more than usually soluble in atmospheric water, carrying carbonic acid—which dissolves all limestones—has at some time been honeycombed by chambers and galleries such as those which traverse the limestone plateau of central Kentucky, of which the Mammoth Cave is an example. Subsequently this rock has been broken through and upheaved by the subterranean forces which have disturbed all our important mining districts, and through the fissures then formed mineral solutions ascended, flowing into any receptacle opened to them. Where these fissures cut an insoluble rock they became, when filled, simply fissure veins; but where a cavernous limestone was broken into, such caverns and galleries as were opened were more or less filled with ore. It has been suggested that the caves now holding ore were excavated by the metalliferous solution, but we find some of them entirely empty, with their sides encrusted with spar, and having all the characters of ordinary limestone caves, and even where the ore occurs, the walls of the cavity have the same character, are hard and unimpregnated with ore. Hence we must conclude that the chambers were formed, like modern caves, by surface water, and when the country was upheaved and the rock shattered only part of them were opened, and that these received the solution and ore, while the unopened ones remained empty. The character of the ore contained in the chambers varies much, as it does in the fissure veins of our mining districts; and the solutions from which they were filled must have been different in the different localities where they occur. Argentiferous galena was evidently the most abundant ore deposited in the chambers, as it is elsewhere; but in some cases this is associated with a large amount of iron sulphide, in others very little; while the ratio of gold to silver is inconstant, and the aggregate of both varies from nothing to several hundred dollars to the ton. The ores of Eureka run high in lead, contain much iron, and about seventy dollars in the precious metals, half gold, half silver. The ores of the Emma mine carried less iron, more lead, much more silver, less gold, and a little copper; while those of the Cave mine at Frisco contain no lead, much iron, a little copper, and are sometimes exceedingly rich in both silver and gold. In all the chamber mines yet worked in this country the ore taken out is thoroughly oxidized, but in the deeper workings of some neighboring fissure veins the soft, ochery ores of the chambers are found changed below into compact masses of galena and iron pyrites; the galena carrying the silver, the pyrites the gold. Hence we may conclude that the ore originally deposited in the caves consisted of sulphides, and that whenever these mines shall be worked below the water level ore of this character will be found. It should be said, however, that if the theory I have suggested of the formation of the limestone galleries is true, they will not be found to extend to so great a depth as the ore bodies of fissure veins, since the excavation of the limestone, if produced by atmospheric water, must be confined to the zone traversed by surface drainage. In a very dry and broken country the line of permanent water level may be very deep, as at Eureka, where the ore bodies extend and are oxidized to a depth of at least 1,400 ft. Such a condition of things could only exist in a very dry climate; but we have evidence that there have been great climatic changes in our western mining districts, according to King and Gilbert, two wet periods having been succeeded by two dry ones, the last prevailing now. We may therefore find chambers wrought in the limestone in a dry period below the present or normal water level. The enormous production of gold and silver from the chamber mines already worked proves the great importance and value of this class of deposits; and while we may predict that they will be found to be more superficial than true fissure veins, still no limit can be fixed to the future yield of mines of this character, even though they should not be profitably worked below 1,500 feet from the surface.

MINERAL VEINS.

Some writers on economic geology—Werner, Von Cotta, and Von Groddeck, for example—enumerate very different kinds of mineral veins, but disregarding the local characters which all ore deposits exhibit, and the hybrids which are formed by the blending of two distinct forms—not of uncommon occurrence, I agree with Whitney in recognizing but three distinct classes, viz.:

1. Gash veins.
2. Segregated veins.
3. Fissure veins.

Gash veins may be defined to be those which occur only in limestone, are confined to a single stratum or formation, and hence are limited in extent, both laterally and vertically. Typical examples of gash veins are furnished by our lead deposits of the Mississippi Valley. These occur at three horizons, viz.: about Galena, in the Galena limestone, belonging to the Trenton Group; in southeastern Missouri, where the mine La Motte is located, in the equivalent of the Calciferous sand rock; and in southwestern Missouri, where the mines of lead and zinc occur in the Lower Carboniferous limestone. The origin of deposits of this character is apparently quite simple. The cavities which form the repositories of the ore are generally the cleavage planes or joints of a soluble limestone rock, that become channels through which surface water charged with carbonic acid flows in a system of subterranean drainage. We usually find two sets of joints approximately at right angles to each other, and vertical if the rocks are horizontal. To form gash veins, one or both of these sets of vertical joints are locally enlarged into lenticular cavities or "gashes," whence the name; but sometimes caves of considerable size, irregular pockets, and vertical or horizontal galleries are formed. These are subsequently lined or filled with ore, sulphides of lead, zinc, and iron, originally disseminated through the limestone, and leached out of it by water which saturates and traverses all rocks in a humid climate. The solution thus formed reaching a cavity, has by evaporation deposited the ore as a lining to that cavity; narrow fissures being, perhaps, filled, walls of larger cavities coated with stalactites depending from the roof, etc. Subsequent solution has sometimes widened a fissure once filled with ore, leaving the ore body as a central partition, a curtain more or less complete hanging from the roof, or a mass of fragments mingled with infiltrated sand and clay in the floor of the cave. In southwestern Missouri the carboniferous limestone contains layers of chert, which are insoluble, and which sometimes form horizontal floors or ceilings of caverns. These breaking down by their own weight, have formed masses of *débris*, cemented together by the ore, which has thus acquired its peculiar brecciated character.

From the description of gash veins given above, it will be seen that they have much in common with the pockets and chambers previously described; but there is this important difference, that the ore filling the gashes and irregular chambers of the leadbearing limestones is indigenous, having been derived from the leaching of the adjacent rock, while in the chamber mines of the West the ore is exotic, having been brought up through fissures from a remote source below; so that, while in physical characters the Western gold and silver bearing ore chambers resemble gash veins, they are really but appendages to true fissure veins, and only occur in a country that has been much broken by subterranean forces.

Segregated veins are confined to metamorphic rocks, are conformable with their bedding, and are limited in extent both laterally and vertically. Their ore bodies form lenticular masses of greater or less dimensions, of which the material is chiefly quartz, which has segregated (*i. e.*, separated) from the surrounding rock. The quartz veins so

* *School of Mines Quarterly.*

abundant in the gneisses and schists of Canada, New England, and the Alleghany Belt, are all examples of this class of ore deposits. The most important constituent of segregated veins is gold, which here seems to have been mechanically dispersed throughout sedimentary rocks, and to have been concentrated with the quartz in the process of metamorphism to which they have been subjected. With the gold we always find iron pyrites, sometimes chalcopyrite, and the latter occasionally in sufficient quantity to be worth working. From these remarks it may be inferred that segregated veins have no deep-seated origin, are less continuous in depth and laterally than fissure veins, and therefore constitute a less permanent foundation for mining enterprises. It may be said, however, that some of them are of enormous dimensions, and that they not unfrequently occur in succession, or so approximate that they are equivalent to a continuous mineral deposit.

Fissure veins occupy crevices which have been formed by subterranean forces and have been filled from a foreign source. They traverse indiscriminately all kinds of rock, and are without definite limits laterally or vertically. They have as characteristic features, smooth, striated, sometimes polished walls, slickensides, clay gouges or selvedges on one or both sides, and a banded or ribboned structure throughout. The vein-stone is usually quartz, and the constituents include the ores of all the metals. The mode of formation of fissure veins is apparently this: In the regions where the earth's crust is broken up in the adjustment of the cold and hard exterior to the cooling and shrinking nucleus, cracks are formed, often miles in extent, along which the rocks suffer displacement, sliding on each other to form what are known as "faults." As the planes of these faults are more or less undulated, with displacement the bearing is upon the projecting bosses of each side. Between these, open fissures are left of greater or less dimensions. These reach down to a heated zone, and form the conduits through which thermal waters flow to the surface. Such waters coming in different localities from different depths, and leaching rocks of various composition under great pressure and high temperature, having great solvent power, become loaded with various mineral matters. As they rise to the surface the pressure and temperature are reduced, and the materials held in solution are deposited to line and perhaps ultimately fill the channels through which they flow. This theory of the filling of mineral veins, *i. e.*, by precipitation from heated chemical solutions coming from below, is supported by such an array of facts that it must be accepted by all who will make a careful and unprejudiced study of the subject. It is true, however, that various other theories have been, at one time or another, put forth for the explanation of the phenomena. Among these, a few deserve a passing notice. They are:

1. *The theory of igneous injection*, according to which the matter filling mineral veins has been erupted like that of trap dikes, and such veins as those of Lake Superior, containing metallic copper, have been suggested as affording good examples. But here we find metallic copper and silver associated, and each chemically pure; whereas, if they had ever been fused, they certainly would have formed an alloy. The copper is also found in crystals of calc spar and other minerals, where it must have been deposited with the other constituents of the crystal, and that crystal formed from solution. Other opposing facts might be cited, but it will be sufficient to say that not one sound argument can be advanced in favor of this theory.

2. *Aqueous deposition from above.* This theory, first advanced by Werner, but since generally abandoned, supposes the contents of mineral veins to have been deposited from a solution which flowed into the fissures from above; but in that case the vein matter should be horizontally stratified, limited in extent downward, and spread over the surface adjacent to the fissure; whereas no one has yet reached the limits in depth of the ore in a true fissure vein, and the characteristic banded structure can only have resulted from successive depositions of a long-continued flow of a hot solution. This theory has been recently advocated in this city by Prof. Stewart, of Nevada; but it is not only not sustained, but really disproved by all the facts observed by the writer in some years devoted to the study of our Western ore deposits.

3. *Lateral secretion.* According to this theory, the material filling all mineral veins has leached into the cavity from the wall rocks. While this is true of gash veins, it can have played but a very subordinate part in the deposition of ore in fissure veins. This is proved by the facts that different sets of fissures which cut the same formation frequently contain very different ores; and where the rocks of totally different character are, by faulting, brought to form opposite walls of fissure, the ore may be symmetrically deposited in corresponding layers. It may also be said that the same fissure frequently traverses several formations, and yet its character may be essentially the same throughout.

4. *Sublimation.* The facility with which certain metals are volatilized, and the fact that various minerals have been deposited from vapor, have formed the basis of this theory; yet it is difficult to see how any one can ascribe more than a local and insignificant effect to this cause. It is true that the action of water, as steam, is much the same as when fluid and highly heated, in the solution and transport of minerals; and the deposit of mercury, sulphide of iron, and even gold, from the mingled water and steam of the California geysers proves this. So we may concede that steam has been an agent in the chemical solution and precipitation of ores; but this is a very different thing from the sublimation of the metals represented by these ores, and all knowledge and analogy indicate that the silica which forms so large a part of vein stones, and is so often seen in combs of interlocking crystals, has been deposited from an aqueous solution. But argument is really wasted in a discussion of the filling of fissure veins, since we have examples that seem to settle the question in favor of chemical precipitation from ascending hot water and steam. In the Steamboat Springs of Western Nevada, for example, we in fact catch mineral veins in the process of formation. These springs issue from extensive fissures which have been or are being filled with silicious veinstone that carries, according to M. Laur, oxide of iron, oxide of manganese, sulphide of iron, sulphide of copper and metallic gold, and exhibits the banded structure so frequently observed in mineral veins.*

In regard to the precise chemical reactions which take place in the deposition of ores in veins, there is much yet to be learned, and this constitutes an interesting subject for original investigation, which I earnestly commend to those who are so situated that they cannot pursue it.

* "Annales dés Mines," Sixth Series, Vol. 3, p. 421.

It may be noticed, however, that the thermal springs which are now forming deposits like those in fissure veins, contain alkaline carbonates and sulphides, and we have every reason to believe that highly carbonate alkaline waters containing sulphureted hydrogen under varying conditions of temperature and pressure, are capable of taking into solution and depositing all the metals and minerals with which we meet in mineral veins.

To these necessarily brief notes on the filling of mineral veins should be added some interesting examples of the mechanical filling of fissures which have been recently brought to light in Western mining. These are furnished by the remarkable deposits of gold and silver ore, the Bassick and Bull-Domingo, near Rosita, Colorado, and the Carbonate Mine at Frisco, Utah. All these are apparently true fissure veins, filled to as great a depth as they have yet been penetrated by well rounded pebbles and bowlders which have fallen or been washed in from above. The porous mass thus formed has been subsequently saturated with a hot ascending mineral solution, which has cemented the pebbles and bowlders together into a conglomerate ore. In the Bassick this ore consists of rich telluride of silver and gold, free gold, and the argentiferous sulphides of lead, zinc, copper, and iron. In the Bull-Domingo and Carbonate mines the cementery matrix is argentiferous galena. That the pebbles and bowlders have come from above is distinctly shown by the variety in their composition and organic matters associated with them. In the Bull-Domingo and the Bassick the pebbles consist of various kinds of igneous rock, mingled with which in the latter are masses of silicified wood and charcoal, while in the Carbonate Mine the pebbles are mainly trachyte; but with these are others of limestone and quartzite.

Fossils and other foreign bodies have before this been found in mineral veins, and Von Cotta mentions the occurrence of quartz pebbles extending to the depth of 155 fathoms in the Grüner Lode at Schemnitz, Saxony, but no conglomerate veins like those mentioned above are known to exist elsewhere, and they constitute another of the many new forms of ore deposit which the exploration of the rich and varied mineral resources of the United States have brought to light. To enumerate and classify these has been the chief object of this article.

In regard to the ultimate source of the metallic matters which give value to our ore deposits but little can be said with certainty. The oldest rocks of which we have any knowledge, the Laurentian, contain gold and copper, which are indigenous; hence, as old as the rocks that contain them, and have been simply concentrated, and made conspicuous in the process of their metamorphism. The rocks are all sediments, and the ruins of pre-existing continents. By their erosion they have in turn furnished gold, copper, iron, etc., to later sediments by mechanical dispersion and chemical solution. We now find gold everywhere in the drift from the Canadian Highlands, and we have every reason to believe that all the sedimentary strata more recent than the Laurentian have acquired a slight impregnation of several metals from them in addition to what they have obtained from other sources, and we may conclude that the distribution of many of the metals is almost universal. Sea water has been proved to contain gold, silver, copper, lead, zinc, cobalt, nickel, iron, manganese, and arsenic; and there is little doubt that all the other metals would be found there if the search were sufficiently thorough. Hence, sedimentary rocks of every age must have received from the ocean in which they were deposited some portion of all the metals, and for the formation of metalliferous deposits some method of concentrating these would alone be required. A pretty theory to explain such concentration through the agency of marine plants and animals has been suggested by some German mineralogists, and amplified by Profs. Pumpelly and T. S. Hunt. Plants have been credited with the most active agency in this concentration, but evidence is still wanting that either animals or plants have played any important part in the formation of our mineral deposits. The remains of seaweeds are found in the greatest abundance in a number of our Palæozoic rocks, and it is almost certain that the carbonaceous ingredient in our great beds of bituminous shale has been derived from this source, and yet we find there no unusual concentration of metallic matter, and none of the precious metals have ever been detected in them.

The metallic solutions which have formed our ore deposits have been ascribed to two sources. One theory supposes that they have drained highly metalliferous zones deep in the interior of the earth; the other, that they have leached diffused metals from rocks of different kinds comparatively near the surface. The latter view is the one that commends itself to the judgment of the writer. However probable such a thing might seem, no evidence of the existence of distinct metallic or metalliferous zones in the interior of the earth has been gathered. On the contrary, volcanic emissions, which may be supposed to draw from a lower level than water could reach, are not specially rich in metallic matters, and the thermal waters which have by their deposit filled our mineral veins, must have derived their metallic salts from a zone not many thousand feet from the surface. The mineral springs, which are now doing a similar work, are but part of a round of circulation of surface water, which, falling from the clouds, penetrates the earth to a point where the temperature is such as to drive it back in steam. This, with fluid water under pressure and highly heated, possessing great solvent power, may be forced through vast beds of rock and these be effectually leached by the process. Should such rocks contain the minutest imaginary quantity of the metals, these must inevitably be taken into solution, and thus flow toward or to the surface, to be deposited, when, by diminished temperature and pressure, the solvent power of the menstruum is diminished. It is evident from these facts that we cannot trace the history of the metals back beyond the Laurentian age. And since we find them diffused in greater or less quantity through the sedimentary rocks of all ages, and also find processes in action which are removing and redepositing them in the form of the ore deposits we mine, it is not necessary to look farther than this for a sufficient theory of their formation.

WIDE DIFFUSION OF COPPER.

DIEULAFAIT has published a memoir upon the existence of copper, in a state of complete diffusion, in all the rocks of primordial formation and in all the sedimentary deposits which are directly derived from the primordial. As principal consequences of this fact he points out: 1. The constant existence of copper in the sea waters of ancient and modern times. 2. The origin and mode of formation of copper ores. 3. The necessary presence of copper in all the mineral waters of azoic regions.—*Ann. de Chim. et de Phys.*

WHY DOES STEEL HARDEN?*

By WILLIAM METCALF, C. E.

IN a late number of *Engineering*, Mr. Jas. Nasmyth expresses suprise that so little attention has been paid to the important property of steel known as "hardening."

The numerous replies informing him how steel hardens, and why steel hardens, show that much attention has been paid to the subject, and that the "whys" given are as numerous as the writers.

Perhaps Mr. Nasmyth has not given much attention to the question himself, and is therefore unconscious of the fact that his "why" may be as deep a mystery and as entirely unanswerable as any other of the multitude of the wherefores in nature, no one of which has yet been solved.

It is not the intention of this paper to give an answer to the question as Mr. Nasmyth puts it, which is possibly unanswerable; but to state what has been done, in the way of gathering facts, preparatory to an attempt to determine what are the chemical or physical changes which occur in the phenomena of hardening, tempering, and annealing of steel.

The inquiry has been pursued diligently by Prof. John W. Langley and ourselves for the past five years, and has been directed exclusively to the gathering of facts, so that as yet we have not even a theory to offer. The inquiry may be divided as follows:

1. The physical structure of steel.
2. The chemical composition.
3. The variations of structure and physical properties due to—

a.—Cooling from fusion.

b.—Effect of work, either by rolling or hammering.

c.—Effect of temperature, and of changes from one temperature to another, as shown by slow cooling.

4. A statement of the various theories of hardening.
5. Some practical conclusions for workers of steel.

1. The physical structure of steel.

In this paper it is to be understood that reference is made only to cast steel.

Steel is crystalline in structure. The size, color, and form of the crystals, when steel is allowed to cool without hindrance from a state of fusion, are governed by its chemical constitution, and are mainly influenced by the quantity of carbon present.

2. The chemical composition of steel.

Steel is mainly an alloy, compound, or mixture of iron and carbon.

Exactly which of these it may be, or whether it is a combination of two or of all three of these conditions, it is difficult to say.

Other elements, as silicon, phosphorus, sulphur, manganese, and so on, are as yet present only by sufferance, and generally it is well known that steel is better without any of them.

The range of carbon in commercial steel may be said to be from about 0·05 per cent. to 1·75 or 2 per cent., but for some purposes of this inquiry we may look at several properties of cast iron as being useful to throw light on the subject.

3. The variations of structure and physical properties due to

a.—Cooling from fusion—as effected by chemical composition, temperature, and rate of cooling.

The structure of steel, and of cast iron, as shown in a fresh fracture of the ingot in one case, or the pig in the other, are remarkable as always indicating the quantity of carbon present, the temperature at which the metal was poured, and the rate of cooling.

As the observation of these phenomena furnishes material for the study of a lifetime, and as they cannot be described properly without the objects themselves, only a few well known facts will be mentioned for use in the latter part of this paper. Cast iron, when poured into iron moulds, hardens just as steel does when quenched in water; this is known as "chilling."

A chill is of silvery white color, bright luster, and consists of elongated crystals generally normal lengthwise to the surface of the mould.

If iron contains little or no silicon, it will chill very deep, or entirely through the mass in small castings.

If much silicon be present it will not chill at all.

If a hard chill, for instance in a hammer die—say two inches thick of chill, be brought to a heat, removed from the fire at once and allowed to cool slowly, it will when broken be found to be softened, but it will retain the marked crystalline form of the chill. This is analogous to tempered steel.

If the same chill be heated red, and kept red hot for several hours, and then cooled slowly, it will be found upon breaking to be an entirely amorphous gray cast iron; every trace of the elongated crystals of the chill will have disappeared.

This is analogous to annealed steel. This experiment is a striking example of iron and combined carbon in the one case, and of iron and graphite carbon in the other case; as these conditions are commonly understood.

This observation is useful in understanding similar changes which occur in steel under the similar conditions of hardened, tempered, and annealed steel.

Steel when cast is almost invariably poured into iron moulds, and the study of fractured ingots is very necessary to the steel maker; but as the ingots very rarely go into the hands of the consumer without previous manipulation, it is hardly necessary to consume time in discussing the characters of the fractures, especially as it requires the actual presence of the ingots to make the description at all intelligent.

It is sufficient to say that we have here an unvarying record of the completeness or incompleteness of the fusion, of the rate and temperature of the pouring, and of the chemical character of the steel, especially as it relates to carbon.

b.—Effect of work either by hammering or rolling.

Steel when heated and hammered or rolled from the ingot has its specific gravity largely increased, its strength is greatly increased, and its grain is made very fine and uniform; this is called "hammer refining," to distinguish it from the refining due to hardening.

An eminent Russian engineer has illustrated this hammer refining beautifully by comparing the hot steel to a certain solution of a salt.

If the solution be allowed to precipitate slowly and undisturbed, very large crystals will be formed; but if it be violently shaken, the crystallization is hastened, and very fine crystals are formed.

* A paper read before the Engineers' Society of Western Philadelphia, January 20, 1880.

So if steel be heated quite hot, but not so as to burn it, and be allowed to cool very slowly, it will form in very large bright crystals and be very friable; but if as soon as it is hot it be taken to a heavy hammer and be thoroughly hammered by rapid and powerful blows at first, and then by lighter blows until it is of the required shape, it will be found to be very fine in grain and very strong.

Therefore, a high softening heat is consistent with good work in forging.

c.—Effects of temperature, and of changes from one temperature to another, as shown by slow cooling or rapid cooling.

The effect of heating steel which has been hammered or rolled is to increase the size of the crystals or grain, in proportion to the temperature, and to reduce specific gravity. There is an apparent or real exception to this increase in size of grain, in steel which has been hardened from the proper temperature to produce what is known as "refining."

In this case the grain is much finer than in the bar, and in this condition any piece of hardened and tempered steel is at its best.

As this refining temperature varies with every different quantity of carbon, no rule can be laid down for determining it; it must be found by actual trial.

But there is no exception in the matter of specific gravity. The specific gravity of refined steel is less than that of the bar, although the grain is much finer. If steel be heated and cooled slowly, it will be softened, that is, annealed.

If it be heated very hot, say to bright yellow, or kept hot a long time, and then cooled slowly, it will still be annealed, but it will be harsh and gritty, will not cut well, and will neither refine well when hardened nor hold a good edge when tempered. The cause of this will be obvious if we remember the experiment of the annealed chill mentioned in the earlier part of this paper. If steel be heated to different degrees, as red, bright red, orange, lemon, or bright yellow color, and quenched, it will be found to be harder, more brittle, and coarser in the grain for each increasing degree of heat, after the "refining" heat has been passed. Below the "refining" heat there will be no useful degree of hardening, and the grain will be variable.

If any piece of hardened steel be heated red hot, and cooled slowly, it will be softened, the grain of the steel will return to its original appearance in the bar, and its specific gravity will be restored to the specific gravity of the bar.

This fact should put a quietus upon all quack nostrums for "restoring burnt steel."

If a piece of steel containing little carbon be alternately hardened and heated and rehardened a number of times, it will vary in volume, but will not sustain regular increases of volume.

If steel of moderately high carbon be repeatedly hardened it will continue to increase in volume until ruptured. This will be illustrated by table No. 5.

Some years ago, twelve ingots were selected by numbers, and analyzed to determine the accuracy of ocular inspection, and were afterwards experimented upon in following up the search for facts in regard to the cause of "hardening."

The specific gravities of these ingots were determined, and the results were given by Prof. Langley in a paper read before the American Association for the Advancement of Science in 1876. Since then bars rolled from these ingots have been experimented upon, and the specific gravities of the bars and of various hardened pieces and of resoftened pieces have been determined.

These experiments will now be described.

Table I. gives the analyses and specific gravities of the ingots.

Table II. gives the specific gravities of six of the bars, and the specific gravities of the same bars heated to various temperatures and hardened.

Table III. gives the specific gravities of the six bars, and the six hottest pieces numbered 1 in Table II., after having been annealed from the condition given in Table II.

TABLE I.

Ingot Numbers.	C.	Si.	Ph.	S.	Fe. by Diff'ce.	Sp. Gr. ingots.
1........	0·302	0·019	0·047	0 018	99·614	7·855
2........	0·490	0 034	0·005	0·016	99·455	7 896
3........	0·529	0 043	0·047	0·018	99·363	7·841
4	0·649	0·039	0·030	0·012	99 270	7·829
5........	0·801	0·029	0·035	0·016	99·119	7·838
6........	0·841	0·039	0·024	0·010	99·086	7·824
7........	0·867	0·057	0·014	0·018	99·044	7·819
8........	0·871	0·053	0 024	0·012	99·040	7·818
9........	0·955	0·059	0·070	0·016	98·900	7·813
10........	1·005	0·088	0·034	0·012	98·861	7·807
11........	1·058	0·120	0·064	0·006	98·752	7·803
12........	1·079	0·039	0·044	0·004	98·834	7·805

Table IV. gives the specific gravities of four pieces all from the same bar after various treatment.

Table V. gives the results of repeated hardening of three pieces of steel containing different quantities of carbon.

Consideration of the tables.

Table I. contains the analyses of twelve ingots numbered in the left hand column from 1 to 12.

The ingots were selected by the eye and numbered as in the table by Mr. Charles Parkin, with a view to varying quantities of carbon only.

It will be seen that the carbon increases with the numbers regularly, but not uniformly.

Although a repetition of the analyses of Nos. 7 and 8 confirmed Prof. Langley in the correctness of his figures, it must be admitted that in this case Mr. Parkin was quite as lucky as skillful, for it is hard to believe in a really observable variation of structure due to a difference of only 0·004 carbon.

In the columns for Si, Ph, and S the entire absence of progressive quantities shows clearly that these elements had nothing to do in determining the characteristic fractures.

The column of iron by difference happens to run with the carbon column, except in No. 11, where the series is broken by the abnormal amount of Si in that ingot. Theoretically, of course, the specific gravities should run with the iron by difference, but they do not do so in ingots 3 and 5. These, however, are the only exceptions; this may have been caused by incomplete or unusually hot melting, or by hot or cold pouring, or by slow or fast pouring.

These exceptions do not vitiate the rule, and only show that no one set of experiments can be conclusive.

The twelve ingots under consideration were hammered to 1¼ inch square bars at one end, and these bars were rolled to 625 diameter round bars.

Six of these bars, Nos. 3, 4, 6, 8, 10, 12, were selected for specific gravity tests; bar No. 2 was lost, or it would have been used instead of No. 3.

Six nicks were made around each bar at one end at intervals of about half an inch.

The six pieces were numbered from 1 at the end to 6.

Each notched bar was then heated until piece No. 1 was scintillating or nearly white hot; No. 2 was yellow hot; No. No. 3 high red hot; No. 4 red hot; No. 5 barely showing any red, or very low red hot; No. 6 black.

This heating was done in each case as slowly and as carefully as possible; the results show the inevitable irregularities attending only one such experiment, yet there is enough of regularity to teach us a great deal.

As soon as the heats were obtained the bars were quenched in water.

The pieces, carefully numbered, both with the ingot numbers and with the numbers giving their order on the bars, were then broken off and sent to Prof. Langley to have the specific gravities determined. In the table the left hand column gives the ingot numbers.

TABLE II.

	Sp. Gr. Pig.	Sp. Gr. Bar No. 6.	Diff.	Sp. Gr. Bar Pc. No. 5.	From Bar, Diff.	Sp. Gr. Bar No. 4.	Diff. from Bar.	Sp. Gr. Bar No. 3.	Diff. from Bar.	Sp. Gr. Bar No. 2.		Sp. Gr. Bar No, 1.	Diff. from Bar.
3	7·841	7·844	0·003	7·831	—0·013	7·826	—0·018	7·823	—0·021	7·814	—0·030	7·818	—0·026
4......	7·829	7·824	—0·005	7·806	—0·018	7·849	0·025	7·830	0·006	7·811	—0·013	7·791	—0·033
6......	7·824	7·829	0·005	7·812	—0·017	7·808	—0·021	7·780	—0·049	7·784	—0·035	7·789	—0·040
8.. ...	7·818	7·825	0·007	7·790	—0·035	7·773	—0·042	7·758	—0·067	7·755	—0·070	7·752	—0·073
10.. ...	7·807	7·826	0·019	7·812	—0·014	7·789	—0·037	7·755	—0·071	7·749	—0·077	7·744	—0·082
12......	7·805	7·825	0·020	7·811	—0·014	7·798	—0·027	7·769	—0·056	7·741	—0·084	7·690	—0·135

	6	5	4	3	2	1
	Not heated.	Low red heat.	Red hot.	High red.	Yellow hot.	Nearly white Scintillating.

The other columns give the specific gravities of the ingots, the bars—No. 6 pieces, and of the other five hardened pieces in order, as numbered in the sketch and explained before.

The differences are, first, the difference between the sp. gr. of the ingots and the bars; second, the difference between the sp. gr. of the bar, or piece No. 6, and each piece successively.

The differences of sp. gr. are given in preference to the actual differences in volume, because the differences in volume run into the infinitesimals, and the mode adopted answers as well for purposes of comparison.

On comparing the ingot and bar we see a decided increase in the sp. gr. of the bar in every case except one, that of No. 4. We have not discovered the reason of this anomaly. The increase in the other cases is due to hot working; this will be shown by Table IV.

It will be observed that the sp. gr. of the bars, except in No. 3, are nearly uniform.

This seemed very strange at first, but it is capable of a very simple explanation. The hardness of steel and its resistance to change of form increase very rapidly with an increase of carbon, and as these bars were all reduced from 3 in. square ingots to ⅝ in. round bars, it is obvious that it required much more work to reduce No. 12 than No. 4 or No. 6; therefore, as hot working increases sp. gr., the greater amount of work produced the greater increase in the sp. gr. of No. 12.

If the sp. gr. of the right hand column pieces No. 1 be compared to the sp. gr. of the ingots, it will be seen that the relation between the numbers is entirely restored by the high heat to which the No. 1 pieces were subjected.

If the sp. gr. of pieces No. 5, 4, 3 be examined carefully sufficient irregularities in the difference columns will be observed to show that the heating was not accomplished in regular gradations in each case, and if it were desired to lay down an exact law of variation due to differences of temperature, it would be necessary to take the mean of a great many experiments.

Nevertheless, several general laws are indicated in this table.

1st. The sp. gr. of the ingot varies directly with the quantity of iron present.

2d. The greater the quantity of carbon present the greater is the amount of work necessary to produce change of form.

3d. The greater the quantity of carbon present the greater is the change in volume due to a change of temperature.

As for example in No. 3 the change in sp. gr., from the ingot to the bar, is only 0·003, and from the same bar to the piece No. 1 the change is 0·026.

While in No. 12 the change in sp. gr. from the ingot to the bar is 0·020, or about seven times that in No. 3, and the change from the bar to the piece No. 1 is 0·15, or, about five times the change in No. 3.

This is, perhaps, the most important observation that can be made on this series of experiments, as it shows us why it is that high steel is so much more liable to crack and break in manipulation than low steel.

We generally say one is brittle and the other is ductile; we now know that the rate of expansion per degree of temperature is much less in low steel than in high steel. Therefore, low steel is much less liable to injurious internal strains than high steel.

TABLE III.

Ingot. Numbers.	Sp. Gr. of bars, No. 5.	Sp. Gr. of burned pieces annealed, No. 1.	Diff.
3	7·844	7·857	+0·013
4...........	7·824	7·846	+0·022
6...........	7·829	7·835	+0·006
8...........	7·825	7·828	+0·003
10...........	7·826	7·824	—0·002
12...........	7·825	7·822	—0·003

(*To be continued.*)

LINSEED ORE AS A PROTECTION FOR IRON.

By Mr. WILLIAM FOSTER, M.A. (Cantab.), F.C.S., etc., Professor of Chemistry at the Middlesex Hospital.

LINSEED oil is a member of a small group of fatty substances having a property in common—that is, of absorbing oxygen and becoming resinous. These fatty bodies consist of an organic acid radical combined with an organic base, the whole presenting a close resemblance in chemical constitution to an ordinary metallic salt. For instance, ferrous sulphate ($FeSO_4$) consists of a base, iron (Fe), combined with an acid radical (SO_4), such radical being characteristic of sulphates. Now, upward of 90 per cent. of ordinary linseed oil consists of a compound (linolein), the base of which is glyceryl (C_3H_5), and the acid radical associated with it is that of linoleic acid. Free linoleic acid has the formula $HC_{16}H_{27}O_2$. The formula of linolein is $C_3H_5 3 (C_{16}H_{27}O_2) = C_{51}H_{86}O_6$. It is also usual to speak of those compounds containing glyceryl as glycerides. In addition to the glyceride linolein, linseed oil contains small quantities of glycerides of the organic acids, elaic, myristic, and palmitic. These compounds are known as elain, myristin, and palmitin. When linseed oil (in the main linolein) is exposed to the air, oxygen is absorbed, with the formation of new products. Two of these have been studied. The linoleic acid radical is converted into that of oxylinoleic acid ($HC_{16}H_{25}O_3$), and this, in turn, suffers further oxidation, giving rise to a neutral, amorphous, and elastic substance resembling caoutchouc, named linoxyn ($C_{32}H_{54}O_{11}$). It is to the formation of these two substances, and particularly the latter, that linseed oil owes its value as a varnish. This tendency on the part of linseed oil to absorb oxygen and pass into new forms is much increased by heating the oil with oxide of lead (litharge). In this process a lead salt of linoleic acid is formed, but the exact nature of the change by virtue of which the "boiled oil" more readily resinifies—that is, passes into a mixture of oxylinoleic acid and linoxyn—is not understood. When linseed oil, either in the natural state or "boiled," is applied as a protective varnish, it is obvious, from the nature of the changes necessary to form a hard skin, that time is an element which has to be considered; and further, that as the outer surface resinifies first, ready access of oxygen to the underlying layers of oil is prevented. The perfect adhesion of the varnish being dependent on the thorough hardening of the underlying layers, everything which retards this result diminishes the usefulness of the oil as a varnish. As a matter of experience it is known that when linseed oil is applied to the surface of wood and of metal (say iron), the oil more readily hardens in the first case than the second. It would appear from this circumstance that some product or products are formed in the oxidation of the oil, in addition to the two I have considered, and that these are influenced (probably removed) by the absorbent character of the wooden surface. For instance, I have not considered the fate of the radical glyceryl (C_3H_5), when its acid radical is oxidized and converted into the neutral substance linoxyn. All evidence on this point is wanting in the researches to which I have referred. There are also the other three glycerides, constituting more than 10 per cent. of the original linseed oil. The practical aspect of the whole question is, that although linseed oil forms an excellent varnish for wood, it is much less useful for iron. That its desirable qualities are those of forming a hard elastic coating, which mainly consists of a neutral principle, such substance being incapable of forming definite chemical compounds with most of the numerous bodies usually employed as a basis for a mineral paint.

Varnishes of the third class, though extensively employed, are never used alone for coating iron work. The members exhibit the characters of those belonging to the two classes we have already considered. In the first place, they contain a solid basis dissolved in some spirituous solvent, such basis being left unchanged on evaporation of the liquid; and, in the second place, one or more of the compounds present gives rise to a solid substance by atmospheric oxidation. The only instance of a varnish of this class which I shall consider is afforded by a mixture of linseed oil and commercial turpentine. Such a mixture is the one generally used in conjunction with metallic oxides for the purpose of preparing a paint. The behavior of linseed oil in this instance is not different from that when exposed alone. The use of the turpentine is chiefly for the purpose of rendering the mixture more fluid, so that it can be more readily applied;

and as the turpentine is in some measure volatile, the varnish (or paint) dries rapidly, in consequence of loss through evaporation of a portion of this component. *Commercial* oil of turpentine is a solution of solid resinous substances in a limpid volatile oil. When submitted to distillation, the resinous substance (colophony) remains behind in the retort while the limpid volatile oil passes over. The latter constitutes rectified turpentine, and when pure has the formula $C_{10}H_{16}$. Its property of easily dissolving resinous substances is well known, and particularly fits it for use as a solvent of such compounds in varnish making. Turpentine is capable of directly uniting with water, forming a crystalline compound. On free exposure to air it partially evaporates while a portion undergoes oxidation, furnishing resinous and other products. The resinous substances chiefly concern us. They are kept in solution in ordinary cases by virtue of the solvent action exercised by the unaltered turpentine. They are known as acid resins, and are identical in chemical character with common rosin or colophony. In fact, the latter is believed to be formed by the oxidation of the volatile oil $C_{10}H_{16}$ in the woody tissue of those trees which yield commercial turpentine. Thus—

$$2C_{10}H_{16}+O_3=C_{20}H_{30}O_2+H_2O.$$

Rosin, or colophony, is therefore not only present in commercial turpentine, but is also produced from the latter by oxidation of its volatile oil. It is a brittle glass-like solid, exhibiting different shades of color according to the temperature employed in its manufacture. Its color ranges from pale yellow to deep brown. The older writers regard it as a mixture of three isomeric acids—namely, pinic, sylvic, and colophoic acids, each of which has the formula $C_{20}H_{30}O_2$. A recent writer on the subject considers rosin to be chiefly abietic anhydride ($C_{44}H_{62}O_4$). Rosin is readily reduced to a powder, is insoluble in water, and combines directly with caustic alkalies to form soluble salts. One of the chief commercial uses of rosin depends on the latter circumstance. Rosin and caustic soda, heated together, form a soluble salt which is largely produced in the manufacture of ordinary yellow soap. Though rosin is insoluble in water, the two are capable of combining together, forming a hydrate when they remain in contact for a length of time. This circumstance interferes with the use of turpentine when employed in preparing paints intended for immersion in water.

TERMITES, OR WHITE ANTS.

Almost all that we know about the habits and instincts of the curious insects called termites, or white ants, is derived from an account published by Smeathman in the "Philosophical Transactions" for 1781. The proceedings of this insect tribe, as detailed in that paper, are so singular that they cannot fail to prove interesting to the general reader.

The termites are represented by Linnæus as the greatest plague of both Indies, and, indeed, they are justly so considered from the vast damages and losses which they cause. They perforate and eat into wooden buildings, utensils, and furniture; and these they totally destroy if their progress be not stopped in time. The destructiveness of these insects is, perhaps, one of the most efficient means of checking the pernicious luxuriance of vegetation within the tropics. No large animals could effect in months what the white ant can execute in weeks; the largest trees which, falling, would rot and render the air pestilential, are so thoroughly removed that not a grain of their substance is to be recognized. Not only is the air freed from this corrupting matter, but the plants destroyed by the shade of these bulky giants of the vegetable world are thus permitted to shoot. In those countries the white ant answers another purpose—they serve as food. In some parts of the East Indies, as well as in Africa, they are considered great delicacies, and are greedily eaten by the natives. The different species of this genus resemble each other in form, in their mode of life, and in their good and bad qualities, but differ as much as do birds in the manner of building their habitations and in the choice of the material of which they compose them. Some build on the surface of the ground, or partly above and partly beneath, and some on the stems or branches of trees, sometimes aloft at a vast height. Their societies consist of five different descriptions of individuals: (1) Workers, or *larvæ*, answering to the neuters of bees, and constituting the most numerous division of the community. They construct the nest and take charge of the young until the latter are capable of providing for themselves. (2) Nymphs, or pupæ, which differ in nothing from the larvæ, except in possessing the rudiments of wings. (3) Neuters, which are known by their large heads, armed with very long mandibles. These much exceed the laborers in bulk, and are in numerical proportion to the latter as 1 to 100. They are the soldiers of the community. (4 and 5) A male and female arrived at their full state of perfection. Each community contains but one of each of these, and they are strictly king and queen, and are exempt from all the ordinary duties devolving on their subjects. When first disclosed from the pupa they have four wings, but, like the ants, they soon cast off these members. They are known from the blind larvæ, pupæ, and neuters, by their having two large eyes. In this form, says Smeathman, the animal comes abroad during or soon after the first tornado, which, at the latter end of the dry season, proclaims the approach of the ensuing rains, and seldom waits for a second or third shower if the first, as is generally the case, happens in the night and brings much wet after it. The quantities that are to be found the next morning all over the surface of the earth is astonishing; for their wings are only calculated to carry them a few hours, and, after the rising of the sun, not one in a thousand is to be found with wings. At this time there are so many enemies on the lookout for them—including ants, birds, carnivorous reptiles, and even man—that it is probable that not a pair in many millions gets into a place of safety to fulfill the first law of nature and lay the foundation of a new colony. Some, however, do escape, and, being found by some of the laboring insects that are continually running about the surface of the ground under their covered galleries, they are elected kings and queens of new states. The manner in which these laborers protect the happy pair from their innumerable enemies, not only on the day of the massacre of almost all their race, but for a long time after, justifies the use of the term "election." The industrious little creatures immediately inclose the favored individuals in a small chamber of clay suitable to their size, into which at first they have but one entrance, just large enough for the workers and the soldiers to go in and out, but much too contracted to be used by either of the royal pair. About this time a most extraordinary change begins to take place in the queen, to which nothing similar is known except in the case of the chigoe and in the different species of the coccus tribe. The abdomen begins gradually to enlarge, and at length acquires such an enormous size that an old queen will have it increased to an extent which equals fifteen hundred or two thousand times the bulk of the rest of her body, and twenty or thirty thousand times the bulk of the laborer (Fig. 3, No. 8). Smeathman conjectures that the animal must be upward of two years old when the abdomen is thus increased to three inches in length; sometimes he has found it twice that size. It has now become one vast matrix, full of eggs, which make long circumvolutions through an innumerable series of very minute vessels. These eggs, when extruded, are instantly removed by the queen's attendants, of which a sufficient number is always found waiting in the adjacent chambers, and carried to the nurseries, which, in a great nest, may be four or five feet distant, in a direct line, and consequently much farther by the winding galleries that conduct to them.

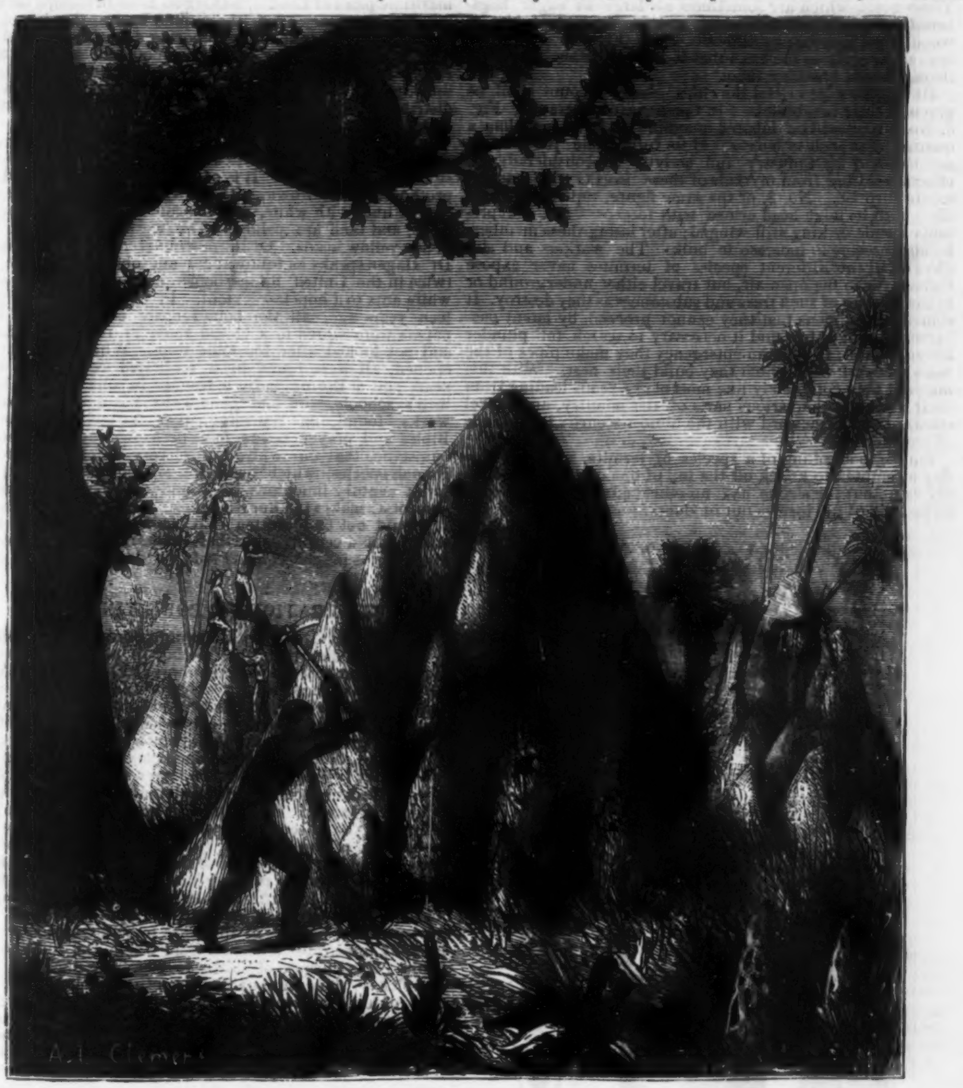


Fig. 2.—NESTS OF WARLIKE TERMITES (*T. bellicosus*) AND TREE TERMITES (*T. arborum.*)

The nests of the "warlike termites" (*Termes bellicosus*) of Africa are usually termed "hills" by the natives, as well as by strangers, from their outward appearance (Fig. 2), which, being more or less conical, generally resemble the form of a sugar-loaf. They rise about ten or twelve feet in perpendicular height above the surface of the ground, and are so solid that wild bulls often mount upon them. Smeathman and his companions used them as observatories to watch for the arrival of ships from a distance. They continue quite bare till they reach a height of six or eight feet; but in time the clay of which they are composed becomes fertilized by the influence of the elements, and in the second or third year the hillock, if not overshadowed by trees, becomes, like the rest of the earth, almost covered with grass and other plants. Every one of these hills consists of two distinct parts—the exterior and interior. The exterior consists of one shell, formed after the manner of a dome, and large and strong enough to inclose and shelter the interior from the vicissitudes of the weather, and the inhabitants from the attacks of natural or accidental enemies. It is, therefore, much stronger than the interior, which, being the habitable part, is divided with a wonderful degree of regularity and contrivance into an amazing number of apartments for the residence of the king and queen and the nursing of their numerous progeny, or are appropriated, as magazines, to hold provisions. These hills make their first appearance above ground by a little turret or two, in the shape of sugar-loaves, rising a foot or more in height. Soon after, at some little distance, while the first turrets are increasing in height, the insects raise others, and so go on increasing their number and widening their bases till the space occupied by their underground works becomes covered with a series of these elevations; the intervals between the turrets are then filled up, and the whole collected, as it were, under a dome. The royal chamber, occupied by the king and queen, is always situated as near the center of the structure as possible, and generally on a level with the surface of the ground. This is surrounded by numberless others of different shapes and dimensions, all of them arched either ovally or circularly, and communicating with each other by passages. These are the waiting-rooms for the attendants which remove the eggs of the queen, and they also lodge the soldiers which defend the colony. Next to these chambers are the magazines, in which are deposited inspissated exudations and juices of trees, serving as food. Intermixed with the magazines are the nurseries, differing totally in construc-

Fig. 1.—TOODSTOOL-SHAPED NESTS OF TERMITES (*Termes atrox*).

tion from any other part of the building, and composed of raspings of wood cemented with gum. There is another African species (*Termes atrox*), about half the size of the one just described, and which constructs nests which somewhat resemble toadstools (Fig. 1). These have a maximum height of about three feet, and consist of a straight cylinder covered with a conical cap which projects about four inches beyond the cylinder. These nests are divided internally into a large number of cells, without any particular arrangement. The "Tree Termite" (*T. arborum*), also of Africa, constructs its nest in trees, in the forks of the branches. These nests, which are sometimes as large as sugar hogsheads, are black and spheroidal, and are formed of bits of wood glued together by different gums (Fig. 2). They adhere so strongly to the trees that it is impossible to detach them without breaking them.

Having now described the cities, some account shall be given of their inhabitants. In the annexed engraving, Fig. 3, No. 1 represents a laborer magnified. It is less than a quarter of an inch in length. If its formidable jaws be examined, and its industry and activity be considered, the effects resulting from myriads of these insects will scarcely excite surprise. No. 2, of the same figure, represents a soldier, with its huge head armed with forceps. No. 6 represents a male or king still winged; after losing these members he never seems to increase in bulk. The workers and soldiers of all the different species of termites never expose themselves to the open air, but travel either underground or in the interior of such trees and substances as they destroy. It sometimes happens that they cannot proceed by latent passages, although they find it necessary to search for plunder above ground; in such an emergency they make pipes of the same material with which they build their nest. With this material they completely line most of the roads leading from their nests into the various parts of the country, and travel outward and homeward with the utmost security in all kinds of weather.

Smith, in speaking of a species of termite, says: "I one day attempted to knock off the top of one of the hills with my cane, but the stroke had no other effect than to bring thousands of the insects out of doors to see what was the

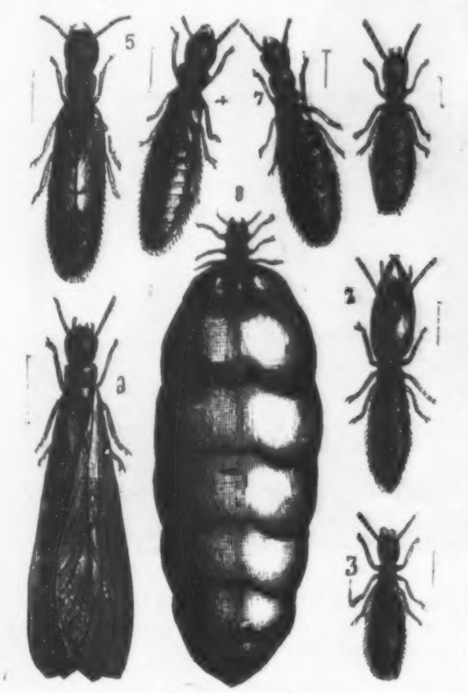


FIG. 3.—VARIOUS TERMITES.

Termes lucifugus:—1. Laborer. 2. Soldier. 3. Larva. 4 & 5. Nymphæ. 6. Male (King.) F. Female.—all magnified.) *Termes billicosus*:—8. Female, natural size.

matter; upon which I ran away as fast I could." "The first object which strikes one upon opening their hills," says Smeathman, "is the behavior of their soldiers. If you make a breach, in a few seconds a soldier will run out and walk about as if to reconnoiter. It will sometimes go in as if to give the alarm, but most frequently may be followed by two or three others, who run straggling after one another; and to them succeeds a large body, which rush out as fast as the breach will permit them; and the number increases as long as any one continues battering the building. It is not easy to describe the rage and fury they show. In their hurry they frequently miss their hold, and tumble down the sides of the hill, but recover themselves as quickly as possible, and, being blind, bite everything they run against, thus making a crackling noise; while some beat repeatedly with their forceps upon the building, and make a small vibrating noise something shriller and quicker than the tick of a watch, and which can be heard at a distance of three or four feet. They make their hooked jaws meet at every bite; and if it should be the leg of a man, a spot of blood, extending an inch on the stocking, follows the wound. Nothing can tear them away, but they must be taken off piecemeal. If, on the other hand, you cease to batter, in half an hour they retire into the nest, as if they supposed the wonderful monster that damaged their castle to be beyond their reach." Smeathman gives the following account of the "Marching Termites" (*T. viarum*). While sauntering very silently in the hopes of finding some sport, he heard on a sudden a loud hiss, which, on account of the many serpents in those countries, is a most alarming sound. The next step produced a repetition of the sound; and then he saw with astonishment and delight, an army of the marching ants emerging from the ground. Their march was orderly and very rapid, and their numbers prodigious. They were divided into two columns sixteen abreast, composed chiefly of laborers, with here and there a huge soldier that appeared like an ox among sheep. Other soldiers kept a foot or two from the column, apparently acting as vedettes appointed to guard against surprise; others mounted on plants or blades of grass, which flanked the main bodies, and, thus elevated a foot or more, looked over and controlled the moving multitude. They turned their heads in different directions whence danger might arise, and every now and then struck their forceps against the plant and produced the ticking sounds already mentioned, to which the whole army answered simultaneously with a loud hiss, and quickened their pace. After proceeding thus for about fifteen paces, the two columns united and sank into the earth. The stream, however, continued to flow on for more than an hour, during which Smeathman watched their movements. The rear was brought up by a large body of soldiers.

A species of Termite (*Termes lucifugus*) was detected in France in 1797 by Rossi. It is found in abundance in the maritime pines of Landes, making its nests in stumps far from inhabited places. From these pine woods the insect has been introduced into the neighboring departments, and into the city of Paris, along with fire wood and building materials. It is very destructive, not only to wood, but also to linen, paper, books, cereals, etc. The same species is also distributed throughout Spain, Portugal, Italy, Sardinia, Dalmatia, Greece, Turkey, Egypt, and Algiers.

In America we have a species of Termite (*T. flavipes*), which is found from Massachusetts southward, under stones, sticks, and in stumps. It is of a chestnut color, head and prothorax black-brown, with brownish antennæ ringed with a paler hue, with white, very delicate wings, and the mouth, tibiæ, and tarsi are yellow. The workers are white, with honey-yellow heads. Of the destructiveness of these insects Dr. Hagen speaks as follows: "I am obliged to state that twice in the United States books have been destroyed by white ants to a hopeless extent. In Springfield, Ill., fourteen years ago, all the bound spare copies of the State papers were stored in a closed room in the State House, and not looked after for some time. When the room was opened, all were found in a mutilated condition. Some years ago a Boston lady, a teacher in one of the freedmen's schools, who had gone away for a vacation of six weeks, found, on returning, that the whole library of Bibles and prayer books had been destroyed. The circumstance that our white ant is very closely allied to the French species, which lives in a similar manner, and was for a century innoxious till it suddenly became a formidable pest, makes the knowledge of the danger imperative. It should not be forgotten that Alexander Von Humboldt stated half a century ago that the rarity of old books in Mexico was in consequence of the depredations of white ants."

OBLITERATION OF PORT-WINE MARK.

WE have received from Balmanno Squire, M.B., London, a pamphlet describing his method of removing port-wine mark without scar, as recently improved by him. The original plan, announced some years ago, was to freeze the surface with ether spray, and make a series of parallel scratches through the small blood vessels with a cataract knife or similar instrument, about the sixteenth of an inch apart, and then make another series of incisions at right angles with the first set. Pressure with the finger was then applied to the scarified surface before it had thawed, and kept up ten minutes or longer. By this means hemorrhage was entirely prevented, no bleeding whatever occurring. One or two repetitions of the operation resulted generally in a perfect cure. Finding, however, that the perpendicular cuts failed to reach some vessels running vertically, he has lately modified the process by cutting under, as it were, or making the incisions obliquely, holding the knife at an angle of 45°. He advises the pressure in this case to be directed somewhat laterally toward the direction from which the incisions are made. The purpose of this is to close the incisions more completely, thus effectually preventing hemorrhage. The only object in avoiding so carefully the discharge of blood appears to be to render the operation neat and seemingly trivial to the patient. When the plan as described is carefully followed, two sittings are sufficient for the perfect removal of the mark, no scar remaining. A large surface may be treated piecemeal, by which the sittings would of necessity be multiplied. Dr. Squire's description of the treatment and its results is given with so much precision, and is so well reasoned withal, that we cannot doubt the efficiency of the method.—*Pacific Med. and Surg. Journal.*

PICROTOXIN IN NIGHT SWEATING.

QUITE recently, picrotoxin, or cocculin, the active principle of cocculus indicus, has been introduced with great success as a remedy for the night sweating which accompanies phthisis. Dr. Munell has employed it at the Royal Hospital for diseases of the chest in twenty cases, with only one failure. The sweating is usually arrested in two or three days, and there is no return for a fortnight or more. Cocculus indicus, the source of this new remedy, is the fruit or berry of the *Anamirta cocculus*, a beautiful climbing plant, which is a native of the Malabar coast and of the Indian archipelago. It is sometimes called the Levant nut, or the "Bacca orientalis." It has some resemblance to the bay berry, and has been recognized as a medicine since the days of the Arabian physicians; but although having powerful and valuable properties it has, in modern times, found little favor as a remedial agent. Cocculus was probably first known in Europe as a poison for taking fish, which it first throws into violent irregular motion and then stupefies. All kinds of fish are killed by it; the barbel, it is said, taking the longest to die. Fish are inordinately fond of the berries, and, when rendered helpless by the dose they have taken, are readily caught. In nearly all civilized countries, the use of cocculus for this purpose is illegal. Cocculus has also been largely employed by unprincipled brewers, partly for giving beer a due degree of bitterness without the use of hops, and partly to give it "bottom" and render it more intoxicating. It gives a fullness and richness in the mouth, and a darkness of color to weak and inferior liquors. In these respects, a pound of cocculus is said to be equivalent to four bushels of malt. Or to a thin brewing of beer, a pound of this drug will give an apparent substance equal to what would be produced by an additional sack (4 bushels) of malt. These tempting qualities have caused it to be used by a disreputable class of brewers who seek to gratify, at a cheap rate, certain wishes and desires of their customers. The active principle, picrotoxin, was eliminated by Bouillay in 1812. It is a white, intensely bitter, crystallizable substance, soluble in water, alcohol, ether, and fixed oils. In its physiological action it is most peculiar. In some respects its effects on the living organism resemble those produced by strychnia. Tonic and clonic spasms of great severity and violence, culminating speedily in death, are induced by large doses. It has been said that the convulsions caused by picrotoxin more resemble the choreic, and those of strychnia, the tetanic; in other words, picrotoxin exerts its influence chiefly on the cerebral centers, while strychnia affects the spinal.

In night sweating, Dr. Munell uses a 1 in 240 solution in water, and of this he gives from one to four minims three times a day. It is best given alone and not in a mixture. A great advantage of the treatment is said to be that it does not make the skin too dry, but leaves it comfortably moist, while not unfrequently atropia seems to parch it up.

REAPING MACHINE CONTEST.

THE trial of harvesting machines for the government bonus of £4,000 commenced on December 17, 1879, at Adelaide, in the presence of about 2,000 persons, including his Excellency the Governor. The crop was in excellent order, and estimated to yield eighteen bushels per acre. Most of the machines worked well, but the American and several others broke down. The second trial was made on the following Tuesday, but as none of the machines submitted complied with the conditions laid down, the government bonus was not awarded. Farmers are not disposed so far to think very much of the improved machines. They are more likely to get out of order, and their draught is considerably greater than the machines in use. The most important of these is the one invented in 1843 by Mr. Ridley, who declined to patent his invention, preferring to confer upon the colony the product of his brains and ingenuity as a free gift. Several improvements have been added since to Mr. Ridley's machine, one of which is possessed by nearly every farm in the colony.

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TABLE OF CONTENTS.